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JPRS L/9340

8 October 1980

USSR Report

CYBERNETICS, COMPUTERS AND AUTOMATION TECHNOLOGY

(FOUO 16/80)

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USSR REPORT

CYBERNETICS, COMPUTERS AND AUTOMATION TECHNOLOGY

(FOUO 16/80)

CONTENTS

Hardware

VTO IZOTIMPEKS ADVERTISES DISK PACKS

Riga AVTOMATIKA I VYCHISLITEL'NAYA TEKHNIKA in Russian No 4, 1980 p 100

[Text] VTO IZOTIMPEKS DISK PACKS

Technical Parameter	YeS 5053	YeS 5261	YeS 5269-type	YeS 5266	YeS 5267
Capacity (Mbits)	7.25	29/58	2.45/5	100	200
Number of disks	6	11	1	12	12
Number of recording surfaces	10	20	2	20	20
Track density (tpi)	100	100/200	100/200	200	400
Recording density (bpi)	1100	2200	2200	4400	4400
Compatible with IBM disk pack	1316	2316	5440	3336	3300.11
Specification #	2864	3564	3562	4337	5653

Exporter: VTO IZOTIMPEKS
Sofiya, ul. Chapayeva, 51. Telephone: 73-61. Telex: 022731, 022732

[412-P]

CSO: 1863

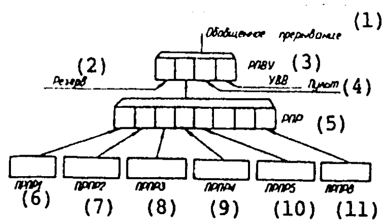
EXPANSION OF THE CAPABILITIES OF A TELETYPE VERSION OF THE ELEKTRONIKA-S5 MICROCOMPUTER SWITCHING SYSTEM

Riga AVTOMATIKA I VYCHISLITEL'NAYA TEKHNIKA in Russian No 3, 1980 pp 50-51

[Article by A. G. Novik, manuscript received 26 Jul 79]

[Text] The Elektronika-S5 family of microcomputers has a multilevel interrupt system. The microcomputer is provided with the standard software and hardware necessary to register and service interrupts in real time. For this purpose a higher level 4-bit interrupt register (RPVU) is provided in which one bit is reserved to display program interrupts. Although the RPVU processes a generalized interrupt named by the program interrupt, its initiation may also be hardware-generated. At the RPVU level, interrupts are processed by microprogram. The generalized signal of the program interrupt is shaped on an AND-gate between the 8-bit program interrupt register (RPR) and its mask. Interrupts at the RPR level are serviced by programs of the teletype version of the switching system (TVDS). For TVDS, the job is the program unit. A software or hardware initiated job program is equivalent to the appearance of the signal "log 1" in one of the RPR digits. Up to eight jobs can be handled simultaneously, two of which are assigned to TVDS. Jobs have absolute priorities. When a lower priority job is interrupted by a higher priority job, execution of the first one ceases and the problem having the higher priority is triggered. Because the general registers are doubly addressed memory cells, the basic information on the interrupted program is automatically retained. The systems table containing the origin of included jobs is generated with the Dispatcher.

To develop very flexible, structured program software for a control system for technological processes, it is inadequate to have the six jobs standardly implemented on TVDS. To expand TVDS, each RPR bit is linked by hardware to the program interrupt preregister (PRPR) from the I/O channel field of the microcomputer (digital inputs and outputs TsVV). Switching by external computer coupling makes it possible to produce such a connection and also process pulsed initiation signals coming from the control object. Each bit of any of the six PRPRs identifies the independent sub-task initiated by the program or by the hardware (hardware connection of jobs is realized by external connections). At the preregister level, sub-tasks have a relative priority in sequence. The



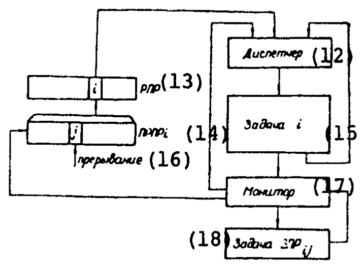


Figure 1. Structural diagram of two-rank interrupt system and its control system. [Key: 1. generalized interrupt; 2. reserve; 3. RPVU, UVV; 4. console; 5. RPR; 6. PRPR1; 7. PRPR2; 8. PRPR3; 9. PRPR4; 10. PRPR5; 11. PRPR8; 12. controller; 13. PRP; 14. PRPRi; 15. job i; 16. interruption; 17. monitor; 18. job ZPR_{ij}].

system can contain up to 48 jobs in all (with a TsVV register 8 bits in length). Sub-tasks of a single group do not interrupt one another, but are executed in sequence, because to retain current information in interrupted programs it would take about 1.5 kbytes of main memory. Interruptions at the level of the preregister are serviced by a re-enterable "Monitor" subroutine which according to the number of the initiating control job, information in the preregister and data in the systems table of preregister jobs transmits control to the corresopnding sub-task (Figure 1). This approach was used in [1].

The process of elaborating program software boils down to specification of program modules which realize independent functions and their connection into the system. In some cases with logically complex and branched technological and computer algorithms it may turn out that 48 jobs are not enough. In that situation, program and hardware support of interruption processing may be supplemented by yet another level of processing. Each PRPR bit is connected to the lower level interrupt preregister (PPNU) from among the remaining free digital input/outputs. For a different application it may not be mandatory to connect all digits of all PRPR to the corresponding low level registers. The maximum number of sub-tasks for the Elektronika S5-01 microcomputer with all possible connections to the PPNU

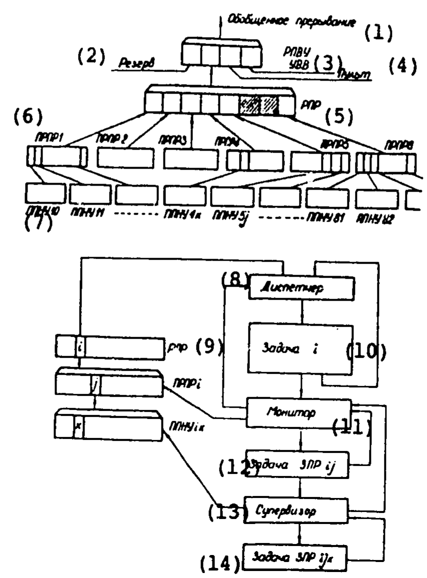


Figure 2. Structural diagram of three-rank interrupt system and its control system. [Key: 1. generalized interrupt; 2. reserve; 3. RPVU, UVV; 4. console; 5. PRP; 6. PRPR1....; 7. PPNU 10....; 8. controller; 9. RPR, PRPRi, PPNUik; 10. job i; 11. monitor; 12. job ZPR ij; 13. supervisor; 14. job ZPR ijk].

is 384, while for the Elektronika S5-02 modification it is 1,536. These computers have different TsVV capacity: S5-01 has 8 bits, S5-02 has 16 bits.

For distributed computing systems based on microprocessors and multiprocessor complexes with many initiating signals, the three-rank structure of the interrupt system is most acceptable (Fig. 2). The systems table for low level jobs may be only partially filled, because the presence of all sub-tasks is not mandatory and is defined by the user in the development of program modules. If some jobs are not fitted in the system, the initial address of the program trap which will return control to the Supervisor should be put in the appropriate line of the job table to increase reliability of program support.

From the standpoint of a standard TVDS Controller, the two systems described do not generate new problems at the control level, but specific subroutines from one of six high level problems. This difference is hidden from the user in the internal organization and structure of programs of interrupt processing. He is given the opportunity to operate with jobs having preset priorities and established service discipline.
The principle of modular programing for the Elektronika-S5 family of

microcomputers is realized by expansion of TVDS with re-enterable programs which may be masked in peripheral memory and be entered into the interrupt processing system by assigning the proper addressses in the control job origin table.

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[399-8617]

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Software

UDC 681.3.06

PROGRAM TESTING USING SYMBOLIC EXECUTION

Moscow PROGRAMMIROVANIYE in Russian No 1, 1980 pp 51-59

[Article by Yu. V. Borzov]

[Text] Program testing using symbolic execution is discussed. Efficient automatic systems for testing programs are surveyed. Problems in developing them are discussed.

From the History of Automation of Testing

The first steps in automating testing were attempts on machine generation of tests using descriptions of the structure of the input data. This was done as early as in 1962 by R. L. Sauder [1], and then developed later by H. T. Hicks [2], K. V. Hanford [3] and others. However, in these cases the tests only externally resembled (in their format) the data that the program was compiled to process. Specific test values were usually generated randomly, and therefore, there was no guarantee that the generated tests would pass through all the branches of the program. Practice showed that this approach found effective application in debugging translators. This is also indicated by the use of this approach in the USSR in RTK [expansion unknown] technology [4]. This approach was not used extensively in programming other types of problems.

From another aspect, development focused on systems automating individual functions of testing. Systems were developed to gather statistics on the program tested (number of executed statements, maximum and minimum values of variables, execution of defined relations between variables, etc.) [5-12]. Some systems could automatically determine the conditions that the input data had to satisfy for the program to execute a given path [5, 13]. Systems [14, 15] produced a set of paths of the program, that contained all branches of the program in the aggregate.

All this information could be usefully exploited when compiling tests, which, however, had to be conducted manually.

Finally, in the mid seventies, several groups independently and practically at the same time developed experimental testing systems using symbolic execution of programs. Some of them had the primary goal of full automation of generating tests [13, 16-24] (in the process, the tests had to purposefully and adequately check out the program, in contrast to randomly generated tests). Others tried to look at the operation of a program not in a specific test, but in a whole class of them. The ultimate goal of this execution is to define the correspondence between classes of input and output data [18, 25-27].

Every programming language has its execution semantics describing: a) the range of definition of program variables (usually these are numbers); b) permissible operations on values of the variables (addition, subtraction, etc. of numbers); c) and rules for transferring control during execution of the program.

It is also expedient to define the so-called semantics of symbolic execution, under which formulas on symbolic values are produced as the results (one can say that we are thus replacing arithmetic with algebraic calculations).

Symbolic Execution, Type I. Let us call a path the finite sequence of program statements $a_1, a_2, a_3, \ldots, a_{k+1}$, if for every $i\ (1 \leqslant i < k)$, transfer of control from a_i to a_{i+1} is formally possible.

The goal of the first type of symbolic program execution is to determine for a given program path what conditions the input data has to satisfy so that control is transferred precisely along this path when the program is executed with this data.

Example. Let us assume the program

```
POWER: PROCEDURE(X,Y);   1
       Z = 1;            2
       J = 1;            3
  LAB: IF Y >= J THEN    4
       DO;Z=Z* X;        5
         J=J+1;          6
         GO TO LAB; END; 7
         RETURN(Z);      8
  END POWER;             9
```

Let us examine what conditions the input data must meet for the path 1, 2, 3, 4, 5, 6, 7, 4, 8 to be executed. This can be tracked if after execution of each statement we record the values of the program variables and the relationships between them (let us call this the status). Then the initial status will appear to us like this:

a) values: $X = \alpha_1$, $Y = \alpha_2$, Z and J are not initialized;
b) relationships: none.

Here α_1 and α_2 are symbolic designations of the input data. Given below are the statuses after execution of statements 2, 3, 4, 5, 6, 7, 4, 8:

2 — a) $X = \alpha_1,\ Y = \alpha_2,\ Z = 1,\ J$ is not intialized,	b) none
3 — a) $X = \alpha_1,\ Y = \alpha_2,\ Z = 1,\ J = 1$	b) none
4 — a) $X = \alpha_1,\ Y = \alpha_2,\ Z = 1,\ J = 1$	b) $\alpha_2 > 1$
5 — a) $X = \alpha_1,\ Y = \alpha_2,\ Z = 1 * \alpha_1,\ J = 1$	b) $\alpha_2 > 1$
6 — a) $X = \alpha_1,\ Y = \alpha_2,\ Z = 1 * \alpha_1,\ J = 1 + 1$	b) $\alpha_2 > 1$
7 — a) $X = \alpha_1,\ Y = \alpha_2,\ Z = 1 * \alpha_1,\ J = 1 + 1$	b) $\alpha_2 > 1$
4 — a) $X = \alpha_1, Y = \alpha_2, Z = 1 * \alpha_1, J = 1 + 1$	b) $\alpha_2 > 1, \alpha_2 < 1 + 1$
8 — a) $X = \alpha_1, Y = \alpha_2, Z = 1 * \alpha_1, J = 1 + 1$	b) $\alpha_2 > 1, \alpha_2 < 1 + 1$

The status after execution of statement 8 contains the necessary and sufficient conditions for execution of the path considered. These conditions are described by the system of inequalities b). It is evident that if only $1 \leqslant \alpha_2 < 2$, then precisely that path considered by us would be executed. If system b) had no solution, this would mean that this path would not be executed with any input data.

In addition to the main problem--determining the conditions imposed on the input data--we also obtained some additional useful information:
1) the parameter of procedure X does not affect execution of the path;
2) the result of the procedure when this path is executed will be the value of the variable $Z = \alpha_1$.

At the same time, we obtained the possibility of generating a test to check this path. It will be a pair of numbers, where the first number is arbitrary, and the second is any solution of the system of inequalities b) at the end of the path 1, 2, 3, 4, 5, 6, 7, 4, 8.

The fact that we symbolically executed a path fixed beforehand starting with its beginning is not significant. The very same information can also be derived when this analysis starts at the end of the path (this is precisely the analysis that was historically suggested earlier [5, 13, 17]). Analysis from the end of the path (trace backwards) generally permits disregarding those variables that do not affect transfer of control. Thus, the algorithm is faster, which is significant in practical realization.

It is true that one can determine in advance those variables in the program that do not affect transfer of control, and then disregard them in the symbolic execution. This is also the usual procedure when execution is started at the beginning of the path (trace forwards) [23]. This method of symbolic execution has the advantage of being able to establish nonexecutability of a path at the point where the error occurs (referencing a noninitialized variable, lack of a solution to the system of inequalities b), etc.), before reaching the end of the path, which is not possible when execution starts from the end of the path.

Symbolic Execution, Type II. The goal of the second type of symbolic execution is to determine by fixed limitations on the input data the path of the program that will be executed with this data, and the symbolic values of the variables at the end of the path.

The ultimate aim (but not always attainable) in this process is to obtain a mapping of the input data into the output data, i.e., the functions realized by the program. Let us take the POWER procedure as an example.

As in the preceding case, let us designate the value of the first parameter by α_1, and that of the second by α_2. Let us assume the following preassigned limitation on the input values: $\alpha_2 < 1$.

It is easy to establish that the status of the variables after execution of statements 1, 2, 3 will be

$$(1) \qquad \text{a) } X = \alpha_1,\ Y = \alpha_2,\ Z = 1,\ J = 1,\ \text{b) } \alpha_2 < 1.$$

This status permits us to determine that the condition $Y >= J$ is false (since from (1), $\alpha_2 \geqslant 1$ is not possible) and, consequently, statement 8 will be executed next. The result of the operation of the procedure will be the value Z = 1.

Thus, it is evident that we succeeded in establishing that in the case of a power less than one (the value of the second parameter of the procedure), the raising to a power is programmed erroneously. Here it is useful to point out that a single test with the initial value of Y = 0 would not detect the error, even though this value is taken from the range of input values just considered.

It follows, however, that through which of the potentially possible paths of the program symbolic execution is to continue cannot always be determined. Taking the above example as an illustration, if the limitation is replaced by $\alpha_2 < 2$ (or the limitation is completely removed), then it would not be possible to determine the path of subsequent execution, starting from statement 4, since two alternatives are possible (when $1 \leqslant \alpha_2 < 2$, control is transferred to statement 5, but when $\alpha_2 < 1$, to statement 8). In this case, both alternatives are usually investigated, i.e., the process of symbolic execution is ramified. How do we establish what path to follow in symbolic execution in the case of branching (IF statement)? Usually, by one of two methods. The first is to take the system of relations with the symbolic input values from the status of the variables prior to execution of the IF statement (let us designate this system α). Add to α the Boolean expression from the IF statement, in which the variables have been replaced by the corresponding symbolic values (let us designate this expression β). The resulting system of $\alpha + \beta$ with rare exceptions, which we shall disregard here, is the system of equalities and inequalities with the symbolic input values. At the same time, let us also form the system $\alpha + \neg\beta$. Let us solve both systems.

If system α has a solution (i.e., there exist input data on which the program will be executed before the IF statement in question), then three cases are possible:

1) $\alpha + \beta$ has a solution, but $\alpha + \neg\beta$ has no solution;
2) $\alpha + \beta$ has no solution, but $\alpha + \neg\beta$ has a solution;
3) both $\alpha + \beta$, and $\alpha + \neg\beta$ have a solution.

In case 1), symbolic execution should continue along the THEN branch; in case 2), along the ELSE branch, and in case 3), along both branches (branching of the process of symbolic execution).

The second method is determined by the formal proof of the theorems.

Let us designate pc (path condition [25]) the conjunction of the relations with the symbolic input data from the status of the variables prior to execution of the IF statement.

Then let us try to prove two theorems: 1) $pc \supset \beta$ and 2) $pc \supset \neg\beta$. At most, only one of these theorems can be true (excluding the trivial case when pc is identically false). If theorem 1) is true, then the symbolic execution should continue along the THEN branch; but if theorem 2) is true, then along the ELSE branch. If neither 1) nor 2) are identically true expressions, then the process of symbolic execution has to be ramified (i.e., both alternatives are considered).

In concluding the description of both methods, let us stress that the branching of the symbolic execution in both cases is linked to the specific execution of the IF statement on a specific path and not to the IF statement itself. Execution of the IF statement on one path may engender branching of the process of symbolic execution, but the next execution of the same statement on another path may not.

Advantages of Symbolic Execution

Using symbolic execution has the following advantages.

1. Symbolic execution of the first type, used to generate tests, makes it possible to form tests purposefully, taking the logic structure of the program into account. Thus, comprehensive checking of the program is possible, for example, automatically compiling tests so that all branches of the program are executed. This compilation of tests is not possible when they are generated randomly.

2. Symbolic execution of the second type enables replacing a large (sometimes infinite) number of executions on concrete values with one execution of the program on symbolic input data. In the process, if the range of program input values can be broken down into classes, where each class contains concrete values, equivalent from the point of view of the program logic, then execution of the program on symbolic values representing these

classes is frequently a complete (and finite) scanning of all possible input values.

Another feature of symbolic execution that must be considered is that output values are expressions with the symbolic input values, i.e., we obtain a more or less exhaustive description of the function realized by the program. When the program is executed on concrete values, it is often practically impossible to establish correspondence between input and output values, i.e., it is almost impossible to determine the function realized by the program by a finite set of pairs (input value, output value).

Systems for Symbolic Execution of Programs and Automatic Generation of Tests

In the mid seventies, about ten systems based on symbolic execution of programs were developed. Some of them have generation of tests as their basic function [17, 19-24], while others are concerned with symbolic execution of a program itself [18, 25, 27]. In the process, the former use symbolic execution of the first type to form systems of equalities and inequalities in symbolic input values (tests are then generated by solving the systems), while the latter use symbolic execution of the second type (primarily to obtain symbolic expressions as values of output variables, i.e., in essence--mapping input values into output). Both these and other systems detect a number of dynamic errors in the process of symbolic execution of the program. Some systems [18, 25, 27] also have facilities to check statements on the program.

Data on the most well-known systems for symbolic execution of programs and automatic generation of tests are given in the table.

Two columns in the table obviously require a more detailed explanation. Column 6 indicates the systems that produce expressions (formulas) with the symbolic input data as a result of the symbolic execution. Column 9 indicates the systems with the capability of checking statements. The statements usually are relations between program variables written in Floyd-Khoar notation and associated with specific points within the body of the program. When control (be it during symbolic or normal execution of the program) is transferred to these points, the system automatically checks execution of the statement. The most advanced in this sense is the SELECT system [18].

Problems of Realization

When the approach of symbolic execution is used for real programming languages, a number of problems are encountered that are common to all or almost all developers of systems based on this approach.

1. The number of program paths, as a rule, is very large, and the length of them is almost always unlimited. How should paths be selected for

System	EFFIGY	SELECT	
Originators	J. C. King S. M. Chase A. C. Chibib J. A. Darringer S. L. Hantler	R. S. Boyer B. Elspas K. N. Levitt	L. A. Clarke
Development Center	T. J. Watson IBM Research Center Yorktown Heights NY	Stanford Research Institute Menlo Park, CA	University of Massachusetts Amherst, Mass.
Batch or Interactive	Interactive	Interactive or Batch	Interactive or Batch
Symbolic Interpretation Type	II	II and I	I
Formulas Produced?	Yes	Yes	Yes
Tests Generated	No	Yes	Yes
Input Language	Subset of PL/1 (integer variables and unidimensional arrays)	Subset of LISP	ANSI FORTRAN
Statements Checked?	Yes	Yes	No
First Published in	1975	1975	1975
Path Analysis Selection Method	User assigns	User assigns or selected automatically within specified maximum path length	User assigns
Comments			Basic function is test generation

	DISSECT	CASEGEN	SMOTL
W. E. Howden	W. E. Howden F. Laub R. F. Hoffman	C. V. Ramamoorthy Siu-Bun F. Ho W. T. Chen Y. W. Han	Ya. Ya. Bichevskiy Yu. V. Borzov M. P. Vasilevskiy A. K. Zarin'sh U. M. Strauyums
University of California, La Jolla, CA	University of California, La Jolla, CA	University of California, Berkeley	Computational Center of the Latvian State University, Riga
Batch	Batch	Batch	Batch
I	II	II	II
No	Yes	No	No
Yes	No	Yes	Yes
FORTRAN	FORTRAN	FORTRAN	SMOD
No	Yes	No	No
1975	1976	1976	1977
Can be selected automatically	User assigns or selected automatically, if maximum number of cycle passages is specified	Selected automatically	Selected automatically
System not completed (only first two units of five have been developed)		System is experimental subsystem of the FACES system	Only one of the systems listed that is oriented to data processing tasks

analysis so that these paths represent the program fairly well? How do you determine when to stop analysis of a particular path if its length is unknown?

The majority of developers solve these problems the simplest way by one of the following methods: a) the user specifies completely the entire path to be analyzed in advance; b) the user specifies in advance the maximum length of the paths to be analyzed or the maximum number of passages through cycles; c) in an interactive mode, the user himself selects the path for analysis and executes it statement-by-statement.

That is how these problems were handled by the originators of the EFFIGY [25], SELECT [18], and DISSECT [27] systems and by L. Clarke [20]. Only the originators of the CASEGEN [21] and SMOTL [28] systems clearly placed no limitations on either the number or length of paths to be analyzed. However, the former formally select paths of greater and greater length until all program branches are covered. Inasmuch as not all of the paths selected this way are executable, selection continues cylicly until all branches are covered. Since this is not always possible (in the case of a branch of the program being unexecutable), this procedure, generally speaking, is not always completed.

In SMOTL, analysis of a particular path stops if 1) under the same program command, the status of the program variables coincide at two different points of the path (from that, it follows that further groups of commands of the path would be repeated cyclicly) or 2) when the path has been analyzed to its end or an error has been detected. Analysis of the entire program ends when all branches have been covered, or all program branches have been passed through one at a time under all possible statuses and it has been detected that because of the nonexecutability of some program branch, full coverage is in principle impossible to achieve.

2. How does one determine the executability of a program path in practice? From the discussion of symbolic execution, it is already known that two alternatives are possible--proof of theorems or the solution to systems of inequalities. In practice, proof of theorems is used only in the EFFIGY [25] system. It is also no secret that the machine programs available today are a long way from perfection. Therefore, the overwhelming majority of the systems in question use various methods to solve systems of inequalities. This approach also has the advantage that while determining the executability of a path, one can generate a test in which the program will pass through this path.

In the majority of cases, linear programming algorithms are used, which of course narrows the class of inequalities that can thus be solved. Thus, at first, the GOMORY [29] and BENDERS [30] linear programming algorithms were tested in SELECT, but then the developers switched to using a variable gradient algorithm which is capable of solving a broad class of systems of inequalities, but in return requires human interaction [18]. In his system,

L. Clarke uses F. Glover's linear programming algorithm [20]. W. Miller and D. Spooner suggest using methods of numerical maximization to generate tests [31].

Two essentially different approaches should also be noted. The trial-and-error method using a random-number transmitter is applied in the CASEGEN system [21]. SMOTL uses a fast algorithm of the method of segments [28], which produces precise results when the values of variables affecting transfer of control are not subject to arithmetic conversions. In the opposite case, a limited scan of values is made, which does not always end successfully. However, this situation is encountered relatively infrequently in data processing programs to which the SMOTL is oriented.

Consideration should also be given to the fact that a good and fast algorithm for solving systems of inequalities largely determines the success of application of the systems in question. Therefore, any practical improvements in this area are welcomed with great interest.

3. How are subscripted variables to be processed? To demonstrate the problem generated by them, let us consider as an example the predicate: a [i + 1] = a [j]. This predicate can be satisfied if we set i + 1 = j or we assign the same value to both variables a [i + 1] and a [j]. If i and j receive input data as values, then it is almost always impossible to solve this uncertainty. Consideration of all potentially possible cases runs into the practically insurmountable barrier of a large number of alternatives.

The simplest solution is to question the user. The developers of CASEGEN found another interesting heuristic approach: in the beginning, the system of inequalities and equalities is solved only for subscripts of subscripted variables, after which subsequent solution is commonplace. In the SMOTL system, only the first four values of a subscripted variable are traced, assuming that in data processing problems, irregular referencing of array elements is extremely rare. It should be mentioned that a satisfactory solution to this problem has not yet been found.

4. How are references to functions and subroutines to be processed? There is no such capability in the majority of the systems in question. In those cases where attempts are made to deal with it (e.g., in SELECT), this is done by a simple insertion of the text of the subroutine into the body of the program to be analyzed; this is in no way satisfactory, since in doing so, the length and complexity of the program to be analyzed are increased and its analysis is thereby hindered.

5. How do you allow for the end of machine operations (in particular, arithmetic)? This question has been practically ignored so far.

We have cited only a few of the problems of realization of systems based on symbolic execution of programs.

* * *

We have discussed program testing systems based on symbolic execution.

Many groups are now working on the development of the systems described. It is hoped that industrial systems for symbolic execution of programs and automatic generation of tests will emerge at the threshold of the eighties. It seems that may make up one of the most intellectual parts of systems for automation of programming and debugging. Efforts in this direction are important for raising the efficiency of programming and the reliability of programs.

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AUTOMATED AND AUTOMATIC CONTROL SYSTEMS

Moscow AVTOMATIZIROVANNYYE I AVTOMATICHESKIYE SISTEMY UPRAVLENIYA in Russian 1979 pp 1-591

[Excerpts from monograph by Dmitriy Georgiyevich Zhimerin and Vladimir Aleksandrovich Myasnikov, 14,000 copies]

[Excerpts] Zhimerin, D. G., Myasnikov, V. A.
Automated and Automatic Control Systems--Second Edition, Revised and Supplemented--Moscow: "Energiya", 1979, 592 pages, illustrated.

Price: 2 rubles 80 kopeks.

The book covers a wide range of problems in improving the planning of economics and management of production of the national economy with the aid of computer technology and automated control systems (ASU). Much attention has been given to the economic effectiveness of using computer technology in the processes of enterprise management. The authors have retained the structure of the book published in 1975 after revising all chapters and adding an additional chapter which deals with protection of information against unauthorized access.

The book is for developers and technical engineering personnel of computer centers and ASU users of all levels. It may also serve as a handbook for students studying computer technology and ASU.

In working on this edition, the authors as before have felt that communication and discussion with leading experts in the country in control systems, economic cybernetics and computer technology were especially valuable for them: academicians N. P. Fedorenko, B. N. Petrov, G. I. Marchuk, A. G. Aganbegyan, V. S. Semenikhin; corresponding-members of the USSR Academy of Sciences D. M. Gvishiani, S. V. Yemel'yanov, G. S. Pospelov, N. M. Moiseyev, prof. V. V. Karibskiy, prof. V. G. Shorin, prof. V. S. Sinyak, candidate of technical sciences R. L. Ashastin and several other scientists.

The authors enjoyed the advice of academician V. M. Glushkov; he is the scientific advisor of many developments in the field of ASU and scientific advisor of the All Union Scientific-Research Institute of Problems of Organization and Control of the State Committee on Science and Technology.

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Please address your remarks in care of the authors: 113114, Moscow, M-114, Shlyuzovaya nab., 10, "Energiya" Publishers.

By the beginning of 1979 230 sector ASU had been put into operation in ministries and agencies.

A certain amount of experience has also been accumulated in the field of ASUP design. Such systems were put into operation by the start of 1979 in more than 2200 associations, enterprises and organizations.

By the start of 1979 more than 1300 systems of automation of technological processes using the computer were introduced. In the 10th Five-Year Plan it is planned to develop and introduce about 1800 automated systems in various sectors and spheres of productive activity.

In communication systems the problem is that its development be contingent not only upon the general need for communication media, but that it also consider the specific requirements of ASU. A substantial increase in the rate of data transmission must be assured and as rapidly as possible it should be implemented in the first stage in telegraphic channels up to 200 baud, and at least 1200 baud in telephone lines. In a subsequent period the rate of data transmission should be increased considerably.

Chapter 6

Statewide Automated System

The decisions of the 25th CPSU Congress on the five-year plan of development of the USSR national economy for the years 1976 to 1980 envisaged a large program of creation and introduction of automated systems for planning and management of sectors, territorial organizations, associations and enterprises. (In the USSR there are about fifty thousand enterprises and more than forty-seven thousand sovkhozes and kolkhozes, tens of thousands of trade institutions, social and cultural institutions, some of which should be covered by ASU. On this basis it has been planned to create a statewide automated system of information gathering and processing for accounting, planning and management of the national economy OGAS (State Control System)).

The technical base for OGAS should be the state network of computer centers and a unified automated network of communications for the country.

A more detailed investigation of the problem of OGAS confirms the timeliness and importance of the decision to create and introduce both sector ASU as well as a statewide system of planning and management [41, 58, 200, 201].

By 1980 automated systems will have been organized and put into operation in virtually all union ministries and agencies.

The number of VTs by the end of the current five-year plan (1980) will exceed 4000. Collective use VTs (VTs KP) will be developed. To avoid terminological confusion, a brief description of the collective use computing center should be given. This is a computing center which makes it possible to use computer capacities remotely in a time-sharing mode for many users having different types of terminals including intelligent terminals containing mini-computers and other small computers.

Because computers impose high requirements on communication channels as concerns both reliability and throughput and because the cost of communications media is relatively high, one of the basic principles in planning OGAS should be the principle of the most economical and efficient use of communications. This principle excludes the approach based on the securing of channels for one to one connection and requires the organization of highly efficient automated commutation of channels and messages.

The quantitative growth of product output and qualitative changes in the technological processes are accompanied by an increase in information required for optimum planning and management of material production. The volume of circulating information in the national economy is equivalent to about 25,000,000 books of 500 pages each. Each year about 60,000,000,000 printed documents appear in the country. Estimates show that by 1990 the volume of information required for planning and management will double or triple.

OGAS is a comprehensive system of operation of automated organs (USSR State Planning, USSR State Supply, USSR Central Statistical Administration, etc.), ASU of sectors, republics, associations, enterprises and organizations, mutually correlated on the principles of organizational, methodological and technical unity.

Moscow should be the site of the main computer control center for switching VTs of automated systems of statewide organs, sectors and agencies. Of course this is one of the possible versions of the technical solution. There may also be others, for example, a data transmission network (OGSPD) will switch channels for the combined operation of VTs, etc.

A certain amount of work has already been completed in the 9th Five-Year Plan in support of organizational, methodological and technical unity of ASU which would interact in OGAS.

First of all, organizational and methodological unity is supported by the standardized principles of ASU design, the structure of information data shaping, unity of representation of technical and economic information, and a standardized system of documentation.

With this aim, the State Committee on Science and Technology in collaboration with ministries and agencies worked out guidelines and standard planning solutions both in OSAU and ASUP as a whole and for specific subsystems.

Second, USSR state planning, USSR state standards, ministries and agencies worked out thirteen standardized documentation systems and the Unified System of Classification and Coding of Technical and Economic Information, including twenty union-wide classifiers. This should all support the unity of the information "language" between various ASU.

Third and last, technological unity is supported by the fact that computers of the Unified System (Ryad type) will be produced which are software and hardware compatible.

The process of unification and standardization of ASU proceeds very slowly in the first phase owing to the insufficient grasp of their essence and depth. Opponents to unification of automated systems view it from technological viewpoints of the sectors or individual productions, and not from the standpoints of control processes based on economic and mathematical economics models.

6-3. Organizational Structure of OGAS

In the organizational respect, OGAS combines ASU of higher levels of production and the GSVTs network spreading into various economic regions and industrial centers of the country.

In the upper level, OGAS will combine the ASU of USSR state planning, state supply, state technology, state construction, the Committee on Labor and Wages, the Committee on Prices, state standards and other committees and union-wide organizations.

All the sector ASU of ministries and agencies will also be a constituent part of OGAS. As was indicated, in the upper level, OGAS contains ASU and their VTs of all union republics.

The principle of design and the number of TVTs [territorial computer center] should be correlated with the existing organizational system of Soviet and party organs. When calculating and designing the TVTs network, the presence of autonomous republics in our country should be taken into account.

TVTs should be divided into five or six categories according to the volume of data bases, calculation operations, capacity and types of computers. The higher category of TVTs will encompass the largest economic regions in terms of product output and in the number of able workers.

It is also possible that TVTs will be established in the largest economic regions which consist of territorially separate computers.

The overall number of territorial VTs should be defined on the basis of two indicators: their greater coverage of administrative and economic regions (centers) and minimal adjustment of expenditures for their creation. Calculations carried out on computer showed that the optimum quantity which meets the above conditions is the creation of about 200 TVTs. At this time there are 123 krays and oblasts and also 20 autonomous republics. Therefore, the version of 200 TVTs solves the most important problem--the formation of automated systems of information gathering and analysis in all administrative centers and its support of the party and Soviet apparatus. The remaining 57 collective-use TVTs may be situated in the largest and most economically developed regions of the country.

The overall number of VTs of all four levels, as tentative calculations show, will exceed 25,000. This number of VTs, however, is still not optimum because the calculations were carried out on the basis of existing computer technology. There is still no adequately deep experience in creating and operating VTs of collective use. The country now has over 3000 local VTs which generally service one organization. The total number of independent enterprises and organizations in the countries exceeds 600,000.

Thus, with 25,000 VTs on the average each of them would have to service at least 25 to 30 enterprises and organizations. The need for organization of collective-use VTs is dictated by their economic effectiveness and advantage over individual computer centers.

[Note: The economic advantage of collective-use computing centers can be seen from the following calculation. If we take, for example, the number of large enterprises in the country as equal to 7000, then it would cost 7,000,000,000 rubles to set up computer centers at each of them costing an average of 1,000,000,000 rubles.]

If in place of 7000 computer centers at enterprises we were to create 2000 collective-use computer centers servicing three to four enterprises each, the total expenditures for creation of computer centers would amount to about 3,000,000,000 rubles (based on additional investments of 30 percent). To this must be added expenditures for equipment of terminal devices at 5000 enterprises costing roughly 200,000 rubles each, which would come to another 1,000,000,000 rubles.

Thus, total expenditures for formation of collective-use computer centers would equal 4,000,000,000 versus 7,000,000,000 rubles necessary to service locally operating computer centers at each enterprise.

To organize a collective-use computer center it is necessary to have a computer which operates in the time-sharing mode and a branched network of terminals set up at the user facilities. To connect many users to a collective-use computer center, it is necessary to set up a multiplexer, modems, adaptors and other technical hardware at the computer center. In the first stage the collective-use computer center can service users in the packet program processing mode. With organization of territorial collective-use computer centers the installation at large user facilities (enterprises) of intelligent terminals should be envisaged--small computers in which calculations can be done when solving simple problems (calculation of wages, personnel data, etc.).

The organizational structure of OGAS is based on the formation of a state network of computer centers, unified automated system of communications (YeASS) and a government-wide system of data transmission.

The unified communication system (YeASS) is a major element of the government-wide system; without communication, it is impossible to connect computer centers and to support normal operation of the OGAS GSVTs. In the event of operation of an automated system of planning and management, it is necessary to communicate with the corresponding data rate; sometimes a disruption between the data rate and speed of the computer to process it is unavoidable.

The statewide system of data transmission as a component of YeASS plays a major part in the creation and normal operation of the OGAS GSVTs. Two functions are imposed on this link: gathering and reduction of data, its transmission along special communications channels of high data rate to the computer centers of the upper levels of the GSVTs.

The message switching centers (TsKS) are used both for gathering information and for reducing it, which is particularly important in the transmission of large information flows. Thus, the TsKS must be set up at junction points in the country where information flows are generated and may be formed.

In the first phase they should be established at industrial centers and in large cities. Message switching centers should be equipped with special devices for reduction encoding and, if necessary, decoding of information.

Also possible is a version which combines message switching centers with collective-use computer centers. This combination is economically justified because the combined version of a message switching center and collective-use computer center requires much lower capital expenditures and operating costs.

Information flows proceeding upwards from the control object to the controlling organ and downwards (feedback) have already reached great size, and the amount of information will continue to increase in proportion to the economics and development of productive forces.

At this time the total volume of economic and control information circulating in the production sphere is roughly estimated to be around 2×10^{13} bytes per year.

Thus, the data rate of this amount of information along communications channels over great distances is of exceeding importance for the normal operation of the OGAS GSVTs. The requirements imposed by GSVTs on the means of data transmission may be satisfied by the creation of a network of high-speed, broadband communications channels. Modern communications channels have a data rate of 48,000 bits/second or more.

For comparative purposes it can be shown that the data rate along ordinary telephone channels equals 1200, 2400, 4800 words per minute, and along telegraph lines up to 200 baud.

For the purposes of supporting a unified technical policy, methodological and programming compatibility of the upper level ASUs being established, the State Committee on Science and Technology has adopted documents mandatory for all agencies*. However, only the combination of ASU into a unified automated system will support the authentic unification and will bring about technical unity of all component ASUs.

* The State Committee on Science and Technology has affirmed guidelines for planning and creation of ASU at sectors and enterprises and standardization of construction and outfitting of computer centers; mandatory algorithmic languages have been affirmed (COBOL, FORTRAN, ALGAMS, PL/1, etc.).

Unification of the first level ASU has another economic advantage because it will make it possible to avoid nonproductive expenditures for creation of reserve capacities of autonomous computer centers and reduce delays for formation and operation of data bases.

As was shown above, the level of OGAS must include: an automated system of planning calculations (ASPR) of USSR state planning, the ASU of USSR state supply, the ASU of the State Committee on Science and Technology of the USSR, the ASU of the USSR Central Statistical Administration (ASGS), the ASU of USSR state construction (ASUS), the ASU of the State Committee of Labor and Wages (ASTZ), the ASU of the State Committee on Prices (ASOITs), the ASU of the Ministry of Finances and State Banks (ASFYu), the ASU of union and union-republic ministries and agencies.

Automated management systems of other union interagency organizations may be connected to OGAS as they become ready and according to a coordinated plan.

With the introduction of the ASU at the Minsk tractor plant, because of the rapid gathering and processing of information, shutdowns in the main conveyor were reduced by 3.1 percent, and labor productivity increased by 4.6 percent.

At the Kazan plant TEPLOKONTROL', after the ASU was put into operation, the coefficient of enterprise operating rhythm rose from 0.7 to 0.89.

The reliability of OGSPD information transmission should be such that the probable appearance of an error is no greater than 10^{-7}.

Automatic vertical exchange of information (from bottom to top with feedback) and horizontally (between republics and economic regions) governs the design of OGSPD in a radial-circular system for mainline directions. The user communication system should be set up on a radial-junction principle.

In order to couple communications channels with peripheral computer devices of all computer centers in OGSPD, a special data transmission device (APD) should be envisaged.

An illustrative example of GSVTs and OGSPD with a conventionally arranged GVTs of sectors, functional organs, republic GVTs and TVTs is shown in Figure 6-1.

8-5. Examples of Organization and Operation of Automated IPS

The mechanization and automation of information processes is more and more determined as the mainline direction for further development of a unified state system of scientific and technical information, whose formation in our country has mainly been completed in the course of the last five-year plan. In the framework of the coordination plan of scientific research work on the problem of creating a GSNTI, affirmed by the USSR State Committee on Science and Technology, in the past five-year plan more than twenty documentation AIPS have been developed and put into industrial operation, about twenty AIPS are in experimental operation. A description of several of them is given below.

An Automated Information System in Science and Technology (ASINIT) was developed and is operating at the All-Union Scientific and Technical Information Center of the State Committee on Science and Technology [75, 76].

The system is designed for reference information servicing of users with material contained in unpublished references: data on newly started scientific research and pilot design studies (NIOKR); reports on NIOKR, dissertations, algorithms and programs for all fields of the natural, precision, technical and social sciences. The ASINIT prepares and publishes editions with the aid of the computer and a phototypesetting machine, retrospective search and selective dissemination of information, preparation of statistical and other data and analytical materials, reviews and predictions.

Information Retrieval Language of a Descriptor-Type System. In the ASINIT, the thesaurus is represented in two forms: as a machine thesaurus on magnetic disk and in the form of books according to branches of knowledge.

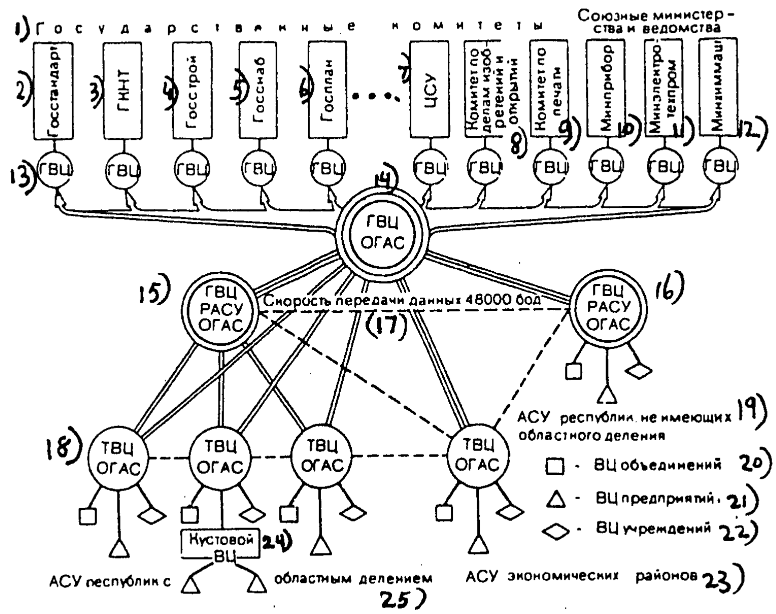

Figure 6-1. Illustrative Diagram of GSVTs and OGSPD

Key:
1) State committees, union ministries and agencies
2) State standards
3) State Committee on Science and Technology
4) State construction
5) State supply
6) State planning
7) Central Statistical Administration
8) Committee on Inventions and Discoveries
9) Committee on the Press
10) The Ministry of Instrumentation
11) The Ministry of Electrical Technical Industry
12) The Ministry of Chemical Machinery
13) GVTs
14) GVTs OGAS
15) GVTs RASU OGAS
16) GVTs RASU OGAS
17) Data rate 48,000 baud
18) TVTs OGAS
19) ASU of republics not divided into oblasts
20) Computer centers of associations
21) Computer centers of enterprises
22) Computer centers of institutions
23) ASU of economic regions
24) Cluster computer center
25) ASU of republics with oblast division.

Information on documents found during retrieval may be printed in the form of document numbers, abstract copies and micro and xerographic copies of the original sources.

A weighted criterion of semantic correspondence with fine gradation and hierarchy of detected documents is used. The ASINIT has been in industrial operation since 1973, and the total volume of the retrospective base in storage is over one million documents.

An Automated System of Information Support of Developments (ASIOR) was developed and is in use at the USSR Academy of Sciences' Institute of Applied Mathematics [77].

The system is designed for gathering, processing, storing, retrieving and printout of documents in the natural sciences (mathematics, physics, radioelectronics, computer technology) in the IRI and retrospective retrieval modes; it has been in industrial operation since 1969. It is constructed in a two-loop principle: in the first loop is storage, retrieval and printout of secondary documents; in the second loop is storage, retrieval and printout of primary documents.

Primary and secondary documents are used as the source data. The system accepts the printout criterion in response to the instruction POD. The printout criterion is formed with the aid of logic gates AND, OR, NOT, and weight coefficients and makes it possible to arrange an output hierarchy.

Information about documents found during a retrieval is printed out in the form of document numbers or bibliographical descriptions. Complete texts of the documents may be ordered by the document numbers and bibliographical descriptions.

The system is built in the BESM-6 and BESM-4 (M-220) computer.

The Descriptor Information Retrieval System Informatika was developed and is in use at VINITI [78].

The system is designed for reference information service of managerial workers of scientific and technical information services of the country supplying them with documents on information in the IRI and retrospective retrieval modes, and has been in industrial operation since 1970.

The system has three loops: the first loop--retrieval images of documents and address codes, the second loop--abstracts, and the third loop--initial sources.

Descriptor-Type Information Retrieval Language. Abstracts are used as the source data. POD represents a list of descriptors. The system adopts the printout criterion upon receipt of the PP in POD; logic operators AND, OR are used. The IPS system Informatika is built in the Minsk-22 computer.

Automated information retrieval system IPS-70 was developed by the Armenian Scientific Research Institute of Scientific and Technical Information and Technical Economic Research (ArmNIINTI), which is a component of the republic's Automated System of Scientific and Technical Information (RASNTI) [79, 80].

The IPS-70 is designed for reference information servicing of specialists in multidisciplinary themes: light industry and food, construction materials, automation and computer technology.

The IPS-70 system has been in industrial operation since 1972.

IPYa of the Descriptor-Type System without Grammar and Lexicon Monitoring at Inquiry Input. A formalized natural language is used as the input language.

In the system an output criterion is adopted to satisfy Boolean formulations of PP.

Information on documents found during retrieval is printed in the form of document numbers or abstracts (according to the output mode).

The IPS-70 is realized on the Minsk-32 computer.

To process information retrieval systems in patent information, in 1961 the Paris Committee on International Cooperation of Patent Agencies in the field of information retrieval was established (ISIREPAT). The USSR entered ISIREPAT in 1966 and is represented by the State Committee on Inventions and Discoveries. The Central Scientific Research Institute of Patent Information and Technical Economic Research (TsNIIPI) has been instructed to participate in the elaboration and operation of ISIREPAT within the international cooperative agreements.

IPS ISIREPAT are designed for carrying out automated retrieval of patent documentation and information support of the state patent examiner; they operate in the retrospective retrieval mode [81].

Information Retrieval Language of the Multidimensional Type in which Retrieval Terms Are Ordered in Categories which Are the Fundamental Concepts of a Given Field of Technology. Generic and specific connections between terms of each aspect are indicated.

Descriptions for patents are used as the source data.

The retrieval pattern of documents is a list of technical aspects and their codes entered in the coding list.

In the IPS the output criterion is adopted for complete entry of PP into POD, and is formulated with the aid of the logic instructions AND, OR, NOT.

TsNIIPI currently has fourteen ISIREPAT IPS based on the Razdan-3 computer.

The sector automated system of information support for light industry Kristall-legprom was developed by the Central Scientific Research Institute of Information and Technical Economic Research of the Light Industry (TsNIITEILegprom) [82-84].

The system is designed for reference information service of scientists, engineers and specialists of organizations and enterprises in the light industry with documental information in IRI and retrospective retrieval modes.

Information Retrieval Language of the Descriptor-Type System with Grammar whose Elements Are Similar to Roll and Communication Indicators. Primary and secondary documents are used in the system as source data. The document retrieval pattern is the totality of information blocks.

In the system the output criterion is adopted for partial entry of PP into POD using weight functions and logic instructions.

Information on documents found in retrieval may be put out in the form of address codes and bibliographic descriptions.

The Kristall-legprom system is implemented on the Minsk-32 and Minsk-22 computers operating jointly.

The Automated Information Retrieval System Ordinata-1 [85,86] is designed for reference information service of users in the IRI, retrospective retrieval modes and preparation of information material access indicators (UPIM) on polytechnical themes; it has been in industrial operation since 1968.

Information Retrieval Language of a Descriptor-Type System without Grammar. Abstracts, brief annotations and bibliographical descriptions are used as the source data.

The document retrieval pattern is an ordered set of descriptors. The output criterion is formulated with the aid of logic instructions AND, OR and NOT. In the event of zero output, self-correction of the inquiry is carried out, providing for sequential exclusion of the logical aspects from the inquiry.

Information on documents found during retrieval is put out in the form of address codes of the documents corresponding to the inquiry, or else as bibliographic descriptions.

This system is realized on the Minsk-22 computer.

The automated IPS Referat [87-89] was developed by the Scientific Research Institute of Control Computers and Systems (NIIUMS, Perm') has been introduced at the Central Scientific Research Institute of Information and Technical Economic Research in Instrument Construction (TsNIITEIpriborostroyeniya), it has been in industrial operation since 1970 and is realized on the Minsk-22 computer using a three-loop system.

Realization of the second phase of OASNTI in instrument construction (since 1975) envisages a change of IPS Referat by IPS Referat-2 based on ASVTM-4030.

Sector Automated System of Scientific and Technical Information IPS TsENTR was developed by the Scientific Research Institute of Control Computers Systems (NIIUMS, Perm') and belongs to the class of Referat-type systems.

The system is operated in several sector, regional and specialized centers of scientific and technical information.

The information retrieval system center is designed for reference information service of users in the IRI and retrospective retrieval modes and also for publishing abstract and signal collections, printing data bases, output of copies of primary and secondary documents.

Information Retrieval Language of a Descriptor-Type System with a Grammar. Secondary documents, mainly abstracts, are used as the source data. The document retrieval pattern is a list of key words with role and context indicators. In the system the output criterion is adopted for accuracy and completeness. In retrieval for accuracy, the output criterion is used for complete entry of PP into POD; for completeness, a logical statistical criterion with partial entry of PP into POD is used.

The retrieval system of automated distribution of information (SARI) was developed and is used by the Central Scientific Research Institute of Information and Technical Economic Research on Atomic Science and Technology (TsNIIATOMINFORM) [90,91].

The information retrieval system SARI is designed for retrieval of documents in science and technology in the IRI and retrospective retrieval mode.

INIS information enters TsNIIATOMINFORM in the form of bibliographic bulletins of Atomindeks, on magnetic tapes and microfiches of documents and is distributed in conformity with SARI inquiries.

Information Retrieval Language of a Descriptor-Type System without Grammar. The thesaurus on atomic science and technology (alphabet coded) contains 6000 descriptors. The lexicon is monitored during indexing of documents and when PP are compiled.

In the system the output criterion is adopted for entry of PP or one of its modifications into POD. The criterion is formulated with the aid of the logic instructions AND, OR.

Information on documents found during retrieval is put out in the form of document numbers. From the card file information cards are manually selected, and their copies are sent to users.

The SARI information retrieval system is realized on the Minsk-22 and Minsk-32 computers.

The automated document factographic system of information service Setka was developed and is used by the Scientific Research Institute of Economics and Information on Radio Electronics (NIIEIRom) [92,93].

The system is designed for gathering, processing, storing, retrieval and output of documents on computer technology and equipment and organization of radio technical production. It operates in the IRI and retrospective retrieval modes and automatically publishes signal indicators on vital problems in the sector.

Information Retrieval Language of a Descriptor-Type System without Grammar. The document retrieval pattern is a list of digital descriptor codes. The output criterion is formed with the aid of the logic instructions AND, OR, NOT.

Information on documents found during retrieval may be put out in the IRI mode (microabstracts) in the RP mode (document number). In conformity with document numbers, the users receive abstract copies. The users have the opportunity to order complete texts of the documents.

The system is realized on the Ural-14 computer.

The information retrieval system Signal-1 was developed at the Division of Information Retrieval System of VINITI and is used at VNIIneftekhim and GIPKh (Leningrad) [94,95].

The system is designed for servicing in the IRI mode of a wide range of chemical specialists with domestic and foreign information in all fields of chemistry entering VINITI. It has been in industrial use since 1974.

The information retrieval language of this system includes IPYa of a descriptor type, UDC, and the language of subject entries.

The document retrieval pattern is the bibliographical description.

In the system the output criterion is adopted for partial entry of PP into POD. The criterion is formulated with the aid of the logic instructions AND, OR, NOT and weight coefficients. The criterion is set by the conditions of correspondence of complete words as well as their fragments.

Information on documents found during retrieval is put out in the form of complete bibliographical descriptions or specific elements.

The system is realized on the types M-222 and BESM-4 computers.

Automated document information retrieval system Elektrotekhnika was developed and is used at the All-Union Scientific Research Institute of Information and Technical Economic Research in Electrotechnics Inform elektro [96,97].

The system is designed for gathering, processing, storing, retrieval and output of documents on electrotechnics in the IRI mode and retrospective retrieval mode and has been in industrial use since 1971.

Information Retrieval Language of a Descriptor-Type System without Grammar. Secondary documents are used in this system as source data.

At the present time documents are retrieved in Russian and in English.

The output criterion is formulated in terms of emptiness or nonemptiness of two characteristic sets of descriptors.

Information on documents found during retrieval is put out in the form of document addresses in two levels "yes" and "maybe". Microfiches and xerographic copies of the abstracts are selected by document addresses and are sent to users.

The Electrotekhnika system is realized on the Minsk-22 and Minsk-32 computers.

Automated information retrieval system in chemistry and chemical industry Argon was developed by the Scientific Research Institute of Technical and Economic Research in Chemistry (NIITEKhIM) with participation of sector scientific research institutes of the Ministry of the Chemical Industry (MKhP) of the USSR and the Department of Electronic Computer Technology of AzNeftekhim imeni Azizbekov (Baku) [98].

The Argon system is operated by NIITEKhIM and sector scientific research institutes.

The system is designed for gathering, processing, storing, retrieval and output of documents on chemistry and the chemical industry.

There are two types of information retrieval language in this system: descriptor language for retrieval of technical documents in the data base and a chemical code language for retrieval according to structural features in the chemical compound data base.

The descriptor IPYa has a grammar and conversion means. A matrix system of linear entries is adopted as the grammar.

The system uses abstracts as source data and the POD is a matrix which includes key words.

In the system the output criterion is adopted for complete entry of PP into the POD, and the logic instructions AND, OR, NOT are used. Information on documents found during retrieval may be put out in the form of document numbers or abstract copies. The document numbers are used to order complete texts of the documents.

The Argon system is realized on the Minsk-22 computer.

Chapter 9

Protection of Information in Automated Systems

9-1. Statement of the Problem of Information Protection

The foreign press has lately given a great deal of attention to the question of protecting data in automated systems. This is because computers have penetrated into almost all areas of human activity and society. The significant ongoing improvement in EDP hardware, the day-by-day spread of these devices in all facets of the economy, technology and management, the persisting efforts to create an all-encompassing data system have turned the question of protection of electronic computer systems into a serious problem.

It turns out that information stored and processed in the computer is highly vulnerable, subject to destruction (erasure, distortion) as well as tampering. For this reason a great deal of attention has been given to studying the vulnerable sites of the computer and automated systems as a whole, in addition to the development of efficient ways and means of data protection.

The urgency of this problem is due to the following factors:

1) An avalanche-like increase in the number of computers in operation.
2) A sudden expansion in the fields of utilization of computers.
3) A continuous increase in the amount of information stored on magnetic carriers and consequently involved in automated processing.
4) Expansion of the methods of user access to the computer including information stored in memory devices.

Computer users are most disturbed by the danger of information leakage. In the United States, for example, in 1973 the costs of stolen documents was estimated at one percent of the gross national product of the United States. In 1963 through 1972 the United States recorded 76 large cases of information leakage from automated information systems, including 15 cases of sabotage, 23 cases of stolen information carriers, 8 cases of duplication and 23 cases of unauthorized connection.

The dynamics of the "crimes" is more fully depicted in Table 9-1.

Table 9-1
Dynamics of Computer-Related "Crimes" for 1964-1972

Type of Crime	Year									Total
	1964	1965	1966	1967	1968	1969	1970	1971	1972	
Total Including:	5	-	1	-	9	9	32	64	13	134
Theft of information and property of VTs	1	-	-	-	2	1	7	20	3	34
Theft of computer services	-	-	-	-	-	1	1	2	2	6
Crimes related to accounts, checks, money	2	-	1	-	3	1	6	10	3	26
Vandalism	-	-	-	-	1	3	6	5	1	16
Incompletely investigated	2	-	-	-	3	3	12	27	5	52

In computer systems and networks colossal flows of information circulate whose contents are often of significant interest for outside persons. It is also information of scientific research projects, data of the economic state of individual companies and whole sectors of production, bank relationships and a great deal else. Information of this type should be closed to unauthorized access. Thus, "protection" may imply a method of guaranteeing safety in a computer system and in a narrower sense the total number of methods and means which control access of programs being executed in the system and information stored therein.

Let us cite some of the numerical data for the United States which justify the need for tackling the problem of protecting information in computer systems.

Let us first describe the data on computer use. In the last 10 to 15 years there has been an avalanche-like increase in the number of computers (Figure 9-1).

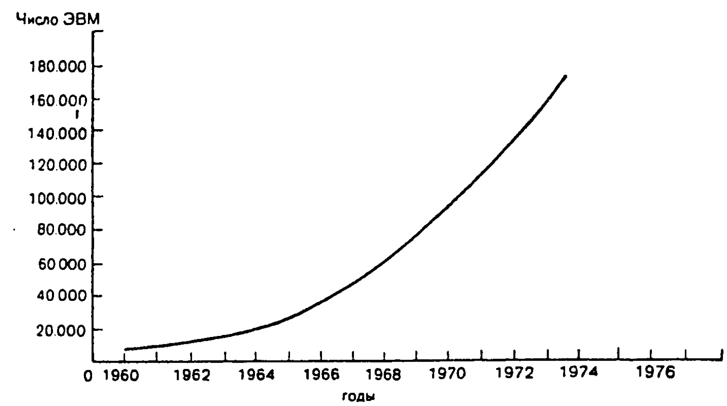

Figure 9-1. Increase in the Number of Computers in the USA for 1960-1975

By 1980 the cost of computer hardware will reach eighteen billion dollars which constitutes fourteen percent of the cost of all types of hardware produced in the United States. A large part of electronic computer equipment will be used directly for processing information. According to estimates of Stanford Research Institute, in 1975 about three percent of the gainfully employed population in the USA (2,230,000 persons) worked directly with computers. In late 1971 24,000 organizations had their own computer, and more than 24,000 organizations used the services of automated information service centers.

At the same time there has been an increase in the number of fields of application of computers. Now, for example, in the United States computers are used in over 200 fields of human activity.

The increased amount of information stored in computer memories is typical. Thus, in the document center of the U.S. Department of Defense there are over one million documents with an annual increase of up to 50,000 documents.

American scientists claim that by the end of the 1970s all information will be stored in the form of microcopies, and work with it will be automated. This suggests an exceptional increase in the concentration of information which also requires reliable protection.

In addition, the improved quality of hardware leads to an expansion in the number of computer users and accordingly the number of methods of access to computer resources.

For example, the SDS 6400 computer can simultaneously interface with up to 1,000 users. Furthermore, electronic computer networks are beginning to be established, which will lead to an even greater number of users. Thus, within the IBM Corporation the AA system has been created which will connect over 300 representations combining about 12,000 users. It is also possible to combine all computer systems into one network.

Finally, the considerable compexity of computing processes also leads to an expansion in the methods of access to information.

9-2. Causes for Leakage and Distortion of Information

The primary causes of destruction and leakage of information are as follows (Figure 9-2):

I. Destruction
   1) Accidents (fires, floods);
   2) Intentional actions (damage of equipment, destruction of carriers).

II. Unauthorized actions (NSD)
   1) Program operator and user errors;
   2) Theft or duplication of information;
   3) Interception from communication lines;
   4) Use of electromagnetic emissions.

III. Reduced reliability of information
   1) Unreliability of data source;
   2) Errors in operator and user work;
   3) Breakdowns in equipment;
   4) Errors in program operation.

The most hazardous natural disasters are fires. Thus, in 1959 a fire which occurred in the Pentagon destroyed equipment worth several million dollars. But even greater losses were related to the destruction of computer programs and data. It took several years to recover the computer center's operating efficiency.

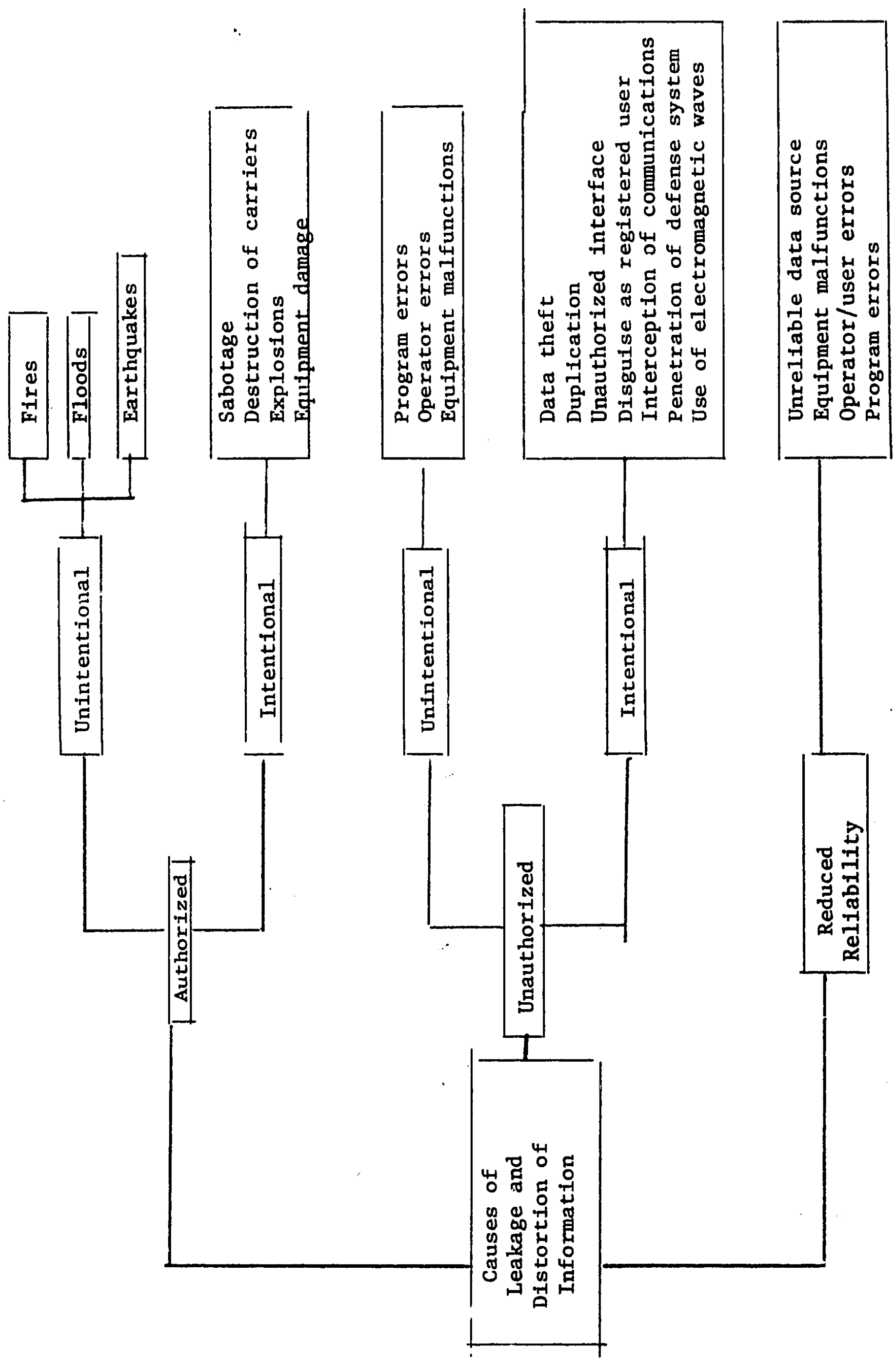

Figure 9-2. Causes of Leakage and Distortion of Information

Equipment operating errors are also substantial because modern computers have low reliability, up to 1,000 hours of good time. This figure is constantly on the rise, but nonetheless errors in equipment operation have a serious effect on the operation of automated systems. The communication lines between the central computer and peripheral devices are a sensitive spot in ASU.

Operating system errors are not detected immediately and in the computer operation process lead to the distortion of output data. Most dangerous are errors in programs and operators which may have fatal consequences. The largest errors are caused by incorrect entry of data and thus a lot of attention should be given to monitoring the correctness of input.

In the foreign literature much attention is given to unauthorized actions because there are many cases of data theft--unauthorized duplication of information, theft of computer operation programs, materials which reveal the operating principles of the computer system, etc. Unauthorized access (NSD) implies the execution by outside persons, users, or service personnel of the ASU to obtain or alter (distort) secret information being processed or stored in the computer which is not required of them in the performance of their service duties, as well as uncontrolled access to ASU hardware.

The foreign literature is full of examples of unauthorized access. At the Encyclopedia Britannica Company operators sold copies of magnetic tape. Computer operation programs and materials which revealed the operating principles of the computer system were stolen, amounting to one hundred million dollars.

Sabotage is very widespread in capitalist countries. Students of one of the universities in the United States erased data contained on 1,000 magnetic tapes. From 1 January 1969 through 15 April 1970 were recorded about 4,000 bomb explosions, 1,500 bombing attempts, 35,000 bomb warnings at computer centers in the USA.

One cause of data leakage may be unauthorized interface to communication lines--both passive and active intercept with request of information through the communication channel.

Waste paper at computer centers, listening devices and photography (with ATsPU it is possible to obtain a photograph at a distance of up to 70 meters) and other methods are also used.

9-3. Classification of Methods of Data Protection

Automated control systems hold a special place among computer systems. In ASU circulate tremendous flows of information of a sociopolitical, scientific and technical, economic and military nature which requires the elaboration of thorough protection methods for reliable information storage.

Current methods of data protection may be classified as follows (Figure 9-3).

The diversity of methods of data protection is attributed to the need of guaranteeing data retention in all components of the computer system and related service equipment. Let us briefly characterize these methods.

Organizational methods of data protection imply the complex of measures relating to persons employed in the computer system. Organizational measures include the entire range of measures of selection and testing of personnel participating in preparation and operation of programs and data, strict control of the process of elaboration and operation of the automated system. These measures are not only an independent protection device, but they also combine all the means and methods into a unified system, an integral mechanism of data protection. Most organizational methods are generally accessible and comparatively easy to implement.

Organizational measures must encompass all elements of the computer system. It is felt that because of the complexity of the protection problem in computer centers, the need has arisen for regular specialists in data protection.

Organizational methods of information protection encompass the following areas:

Organizational measures of protection in construction and equipping of computer centers;
Organization of traffic;
Organization of computer center fire protection;
Selection and training of computer personnel;
Organization of shift work at computer centers;
Organization of observation system at computer centers;
Organizational measures of protection for insertion of changes to the mathematical software;
Planning of measures for data protection;
Problems of officials responsible for data protection.

The hardware part of the system includes computers and equipment directly related to them. The protection system requires that hardware have some features.

In computer devices and other hardware used in automated systems circuits are structurally envisaged to provide protection and control of information. The so-called data parity check system is the most typical: it permits detection of data distortion which occurs during transmission between various computer devices as well as devices which localize electromagnetic emissions.

The central processor should have two classes of instructions: systems instructions and computer instructions. The set of systems instructions should be followed only under the control of the operating system and

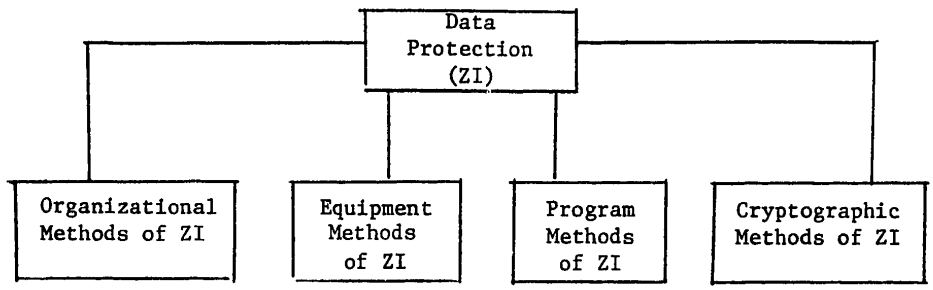

Figure 9-3. Methods of Data Protection

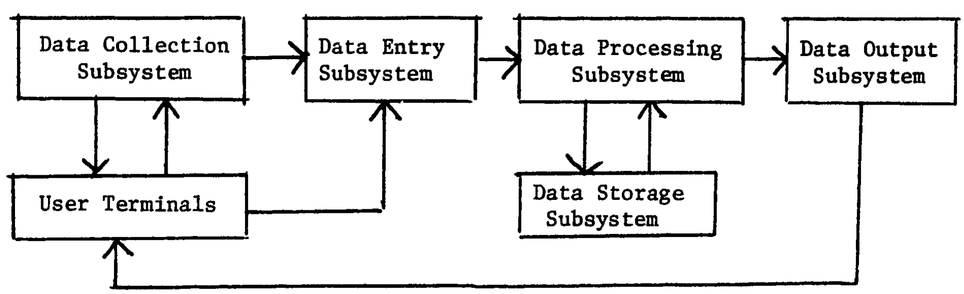

Figure 9-4. ASU Data Flow Chart

should contain input-output instructions and memory protection instructions. Thus, to carry out the input-output instruction, access to the operating system is required. The central processor and the main memory should be organized so that after the operating system is loaded, no other program can utilize the set of systems instructions.

Memory protection devices should include readout and entry blocking in the portion of memory which is occupied by the operating system.

Memory protection devices should protect against intentional or unintentional entry where the protected portion of the operating memory could be destroyed. There may also be a place in memory for code words and safety tables.

The terminal from which the data base may be accessed can be interfaced to a system only through a specific key, code word, or special card. It is also possible to combine the code word and identification card. The valid period of code words should be limited.

Variable systems of code words, code words with a limited number of terminal connection times, hierarchical code word systems where higher code words include lower code words, and other systems are sometimes used.

To prevent interception of data when they are being transmitted between terminals and the computer, technical restricting devices and communication cable screening are used.

To enhance the reliability of data protection, special programs are widely used which make up program protection. The heart of the computer is its operating system, and it should contain the basic programs of safety guarantee.

Programs for information protection according to their function can be divided into the following groups:

Limitation of access to the system, i.e., identification of terminals, users and definition of their privileges;
Guarantee of protection of files, including identification of privileges for utilization of certain information;
Protection of the computer operating system and user programs;
Auxiliary programs which provide solution of specific protection problems of stored data such as addition and alteration of access tables and production of data on the use of protected data and programs, recording of unauthorized and incorrect inquiries, etc.

A great deal of attention has recently been given to the search for new, improved programming methods for destroying data remaining on magnetic carriers after they have been initially erased.

Cryptographic methods are used to protect data when it is being transmitted along communications channels (for example, between user terminal and computer), when it is stored in computer memory devices. It is worth noting that encoding and decoding devices are very expensive. Therefore, sometimes for a group of terminals situated near each other but far from the computer a small connection computer is used which encodes and decodes data. A connection computer is used to collect messages from the user terminals, encode them, and transmit them in encoded form to the main computer. Upon reception of encoded information, the connection computer decodes it and transmits it to the appropriate terminals.

Cryptographic methods are a potentially powerful means of data protection. The questions now being studied on the use of methods of data encoding in computer networks and methods of data encoding are being elaborated for sampling of bit lines and portions of random selection from the text library. However, the discovery of a method which will be simple and rapid and which would be difficult to decipher is a complex task.

9-4. Problems of Insuring Information Safety in ASU

This problem will be considered with respect to the functional diagram of information flow in ASU, which is shown in Figure 9-4.

Possible causes of information leakage in ASU may be considered with respect to the elements of this functional diagram (see Table 9-2).

Table 9-3 indicates the basic problems of data protection in ASU and methods which can be used to solve these problems. This information shows that protection of data is related to the solution of complex organizational and technical problems.

Because the problem of data protection is related to random factors, the absolutely precise determination of the degree of system protection is impossible. We can only speak of a probable evaluation (reliability) of data protection. Thus, the effectiveness of data protection may be estimated on the basis of a probability approach.

9-5. Classification of Protection Schemes

In constructing a protection scheme, it is convenient to use the following classification of possible violations.

Unauthorized use of information. In this case a user not having authority for access to information has the opportunity to become familiar with information stored in a computer, to observe its passage through the system and analyze the information flows, use the programs of other users without having permission for this.

Unauthorized alteration of information. A user inserts changes into information stored in the computer without permission. This process may occur even without direct access to the distorted information.

Unauthorized blockage in access to information. The following are related to this type of situation: premeditated interruption of normal operating conditions of the computer, distortion of system program algorithms, diversions at computer centers. The disturbance prevents access to information and its modification by other persons, although access itself does not occur.

These cases are complex because the violator may be an authorized user of the system.

The above information proves that protection of information involves the solution of serious technical problems because the system which supports

Table 9-2
Possible Causes of Information Leakage in ASU

ASU Elements	Destruction of Information	NSD	Reduced Reliability
Information source	Equipment damage	Data theft	Lack of reliable source Transmission of incorrect information Equipment errors
Users	Equipment damage	Disguise as registered user Unauthorized interface User error	Equipment malfunctions
Communications channels	Destruction of channels	Interception from communications lines User of electromagnetic emissions Unauthorized interface	Inserted noise
Computer complex	Accidents	Unauthorized operator Actions of service personnel	Equipment malfunctions
	Destruction of carriers Destruction of equipment Equipment malfunction	Program errors Operator errors Data duplication Data theft Use of electromatnetic emissions	Program operation errors Operator errors

APPROVED FOR RELEASE: 2007/02/08: CIA-RDP82-00850R000300040020-2

Table 9-3
Problems of Information Protection in ASU

Problems of Information Protection	Organizational	Equipment	Program	Cryptographic
Accident protection	+			
User/operator identification	+	+	+	
Terminal identification	+	+	+	
Verification of access privileges	+	+	+	
Recording of access to data	+	+	+	
Signalling unauthorized access	+	+		
Central processor protection	+	+		
Operating system and user program protection	+		+	
Memory protection (limitation of access)	+	+	+	
Off-line memory protection	+	+	+	+
I/O system protection	+	+	+	
Communication line protection	+			+
Shielding against electro-magnetic emissions	+	+		+
Protection of protection mechanisms	+	+	+	+
Guaranteeing data reliability	+	+	+	+

safety should not permit unauthorized access to data. It is hard to prove that the system satisfies this requirement because this would require prediction of any kind of potential threat. In view of the diversity of functional properties of systems, there are many different systems and mechanisms for information protection. Thus, it would be wise to classify protection systems in terms of their functional properties.

1. Systems without protection schemes. Such systems may have good devices for detection and prevention of critical errors. We may state that any disturbance of conditions is the result of premeditated intervention, and not errors because there are no devices which hinder the user from access to stored information. We cannot consider that any kind of safety is guaranteed in such systems.

2. Systems constructed on the basis of "all or nothing". Systems provide complete isolation of users from one another with respect to the information they use. There is only some limited information (for example, a library of standard programs) accessible to all users.

3. Systems with unified protection scheme. In these systems for each data base there are usually lists of users with the privilege of access (entry, readout, execution, if the base is a program). Realization of these protection schemes is rather complex.

4. Systems with programming of protection scheme. The methods of protection in the systems are determined by the user specifications (for example, designation of a strict order of access to data, definition of access time to information, insertion of changes only with authorization of several users). The user may select any form of program monitoring of access to his facilities by creating protected objects and protected subsystems. A protected subsystem is a set of programs and data such that the privilege of access to data (protected objects) is given only to programs in the subsystem, and access to these programs is only possible from previously defined entry points.

The level of this protection has been realized to some degree in the most improved systems (Multics, Cal, Unix, BCC-500, Cap, Hydza).

5. Systems with restriction. In computer systems this type of protection is now rarely found. The use of information restriction is applicable when it is placed in peripheral memory, in transmission along communications channels. Sometimes output documents contain a secrecy classification for the maximum level of secrecy.

Although the opportunities for using information restriction are rather great, when encoding methods are used and developed, there are tremendous problems. This also retards their wide practical use.

A major factor in protection methods is their dynamicity, i.e., the possible change and addition of rules of access to data. This leads to a significant complexity of the protection system and thus these systems in practice are distinguished by the solution of the problem of dynamics of protection. At the same time, it is clear that questions of dynamics of the scheme and means of protection should be given as much value as the selection of the information protection scheme itself.

For any protection scheme, its effectiveness is determined by the ability of the system to block unauthorized actions. Experiments in a large number of various general-purpose systems have shown that a user is able to elaborate programs which provide free access to any information in the system. This is related to the fact that in any system built on the basis of protection requirements errors are inevitable which give rise to bypass means of access to information.

Work is now being done to develop methods to find such errors according to specific rules.

9-6. Basic Principles of Elaboration of Protection Methods

Accumulated experience on the design of protection methods makes it possible to set forth several principles which aid in the design of high-quality protection schemes.

1. Systems approach in elaboration of protection measures, universality of control. The problem of controlled access should be solved at the overall systems level, i.e., protection is necessary for all operating modes, for all elements of the structural arrangement of the system, including malfunctions, startup and disconnect, preventive maintenance, with reliable recording of the source of any access.

2. Principle of potential closure of the system (Gleyzer's principle, 1965). Normal conditions include the absence of access, and the protection circuit should be based on conditions where access becomes possible. An error in the protection circuit constructed on the basis of the use of permissions leads to an expansion of the sphere of activity of prohibitions, which can easily be detected. This error does not violate the principle of design of protection.

3. Simplicity of the protection mechanism. To avoid errors in planning and realization, it is necessary to have the opportunity for instruction verification of programs or detailed verification of electronic circuits used in the protection circuit, which is only possible for simple, compact circuits.

4. Knowledge of the protection mechanism should not yield information about possible penetration of the system. It is impossible to restrict details of system realization for wide use. Furthermore, restriction of protection methods leads to an increase in expenditures and risks related to penetration of the system. Thus, both sides of the question should be considered in approaching realization of this principle.

5. Principle of division of authorities. The system where the protection mechanism is designed for the use of two keys instead of one is more reliable and flexible. These two keys may be used and transmitted under the responsibility of different programs or users.

This method is used in the storage of bank safes, in missile defense systems where for use of nuclear armament the proper instructions must come from two different persons, in computer systems where the privilege of access is determined by execution of two or more conditions.

6. Principle of minimum authorities. In a system for any program and any user the minimum range of authorities necessary to execute the instructed work is determined. This reduces the damage caused in malfunctions and accidental disturbances. Tracking down cases of violation of authorities is limited to the largest group of suspected programs.

7. Maximum individualism of the protection mechanism. The number of parameters and characteristics of the protection system common for several users is reduced to the minimum, which reduces the possibility of data exchange between users.

8. Psychological appeal. It is important that the protection system is simple to use, and does not require any artificial languages to deal with it.

9. Labor intensiveness of penetration into the system. A direct evaluation of this factor is impossible in most cases. When evaluating the risk of penetration into a system, one usually begins with the possibility of potential violators.

10. Registration of penetration. The date and time of the last access to each data base is often recorded in systems, but if protection is violated, it's impossible to guarantee the reliability of this information.

11. Principle of dynamicity of protective means--possible change in addition of information protection measures adopted in the system.

9-7. Protection Against Electromagnetic Emissions

Protection against electromagnetic emissions relates to the equipment methods of protection used in automated systems, but in view of the importance of this question, it will be examined in a separate section.

American experts feel that electromagnetic emissions are a serious channel of information leakage in the operation of computers and other hardware. Electromagnetic signals may be intercepted, decoded and be represented as an information flow.

The most important and informative source of emissions is the central processor, memories, input/output devices, communications channels, as well as the switching centers for connection of users to the computer.

Operation of the central processor in terms of its electromagnetic emissions is similar to the operation of a low power, shortwave transmitter. In the presence of the appropriate equipment and in the absence of background noises, each change in position may be established. But in view of the fact that the current of the working circuits are rather small, the circuits themselves often are screened and have a rather strong background from a large number of simultaneously operating circuits: it would be difficult to decode the electromagnetic signals of the central processor.

Much less protected by the computer system itself are the magnetic core memories, magnetic discs and magnetic tape. For entry of information in the memories requires pulses having relatively great amplitude. The signals may be received by the corresponding equipment and analyzed.

American experts feel that it is comparatively easy to decode these signals for computers having a serial principle of operation, while it is more difficult for computers using the bit structure of words, and it's very difficult for computers having parallel operation.

For the terminal input/output devices the characteristics of the electromagnetic emissions depend on the type of terminal.

It has been noted that analysis of electromagnetic emissions of these devices is simpler than other susceptible points in the system.

An important source of information may be the unprotected communications lines. When pulsed signals with high amplitude flow through them, there is emission of electromagnetic signals which can be established and analyzed.

Equipment in the switching center may be situated in a computing center or be part of the telephone communications system used both in the switching center itself as well as the communication lines of the center with the user or computer yielding a reliable data source.

Furthermore, it is possible to use equipment which records interface to the communication lines of additional devices which may intercept valuable information.

9-8. Order of Elaboration and Introduction of Measures To Protect Information

A program to introduce devices, methods and measures to protect information which they follow in the USA when elaborating and operating automated systems includes the following:

1. Establishment of the necessary degree of protection of information.
2. Designation of persons responsible for execution of measures to protect information.
3. Definition of possible causes of information leakage.

4. Earmarking of funds.
5. Designations of the person responsible for the elaboration of the information protection mechanism whose duties include: prevention of errors in equipment operation in packet data processing, real-time operation, remote data processing, controlled use of data bases, equipment breakdowns;

Prevention of information leakage, i.e., definition of methods of recognition of users, structure of the recognition circuits, need to use cryptographic methods of protection which prevent unauthorized entry into the system, need to use protection programs, order of utilization of data bases, methods of systems function control, methods of restoration of equipment efficiency after breakdown.

6. Establishment of responsibility for elaboration of procedures, i.e., definition of the structure and functions of the data input/output control section, the achieved degree of control of operation, procedures being done in the computer room, in the data base library, order of execution of procedures to improve the system.

7. Establishment of responsibility for control of program use, i.e., definition of methods to prevent unauthorized use of programs and the order of program testing.

8. Establishment of responsibility for execution of organizational measures of protection, i.e., preservation, traffic and prevention of sabotage, storage of data bases, organization of fire defense measures, and usage of measures to prevent unauthorized interface and tapping.

9. Establishment of responsibility for administrative control of processing programs of especially important data, use of service documents, systems insurance, procedures carried out in various emergencies.

10. Establishment of control over verification of measures being carried out to protect information in the stage of elaboration of the protection mechanism and elaboration of the control list of verification of protective measures during a system operation.

The sequence and contents of elaboration of the protection mechanism used by American experts include the following questions:

Composition of the list of data which should be protected; evaluation of expenditures in information leakage, its destruction, appearance of errors; composition of the list of possible causes of destruction, errors, channels of information leakage; evaluation of the probability of destructions, errors, data leaks in each channel; analysis of possible methods of protection against destruction, errors, data leakage; justification of advisable methods of protection; elaboration of a set of means and methods of data protection.

Measures to ensure safety may be very expensive, both from the viewpoint of the efforts of individuals as well as from the viewpoint of computer time expenditures since authorization of access and control over access to data require nonproductive expenditures. Programs to ensure safety may use up to two percent of the operating time of the central processor.

When defining the minimum volume of measures necessary for protection, we should take into account the value of data which will be protected. If it costs more to protect the data than they are worth, then we might consider that this protection device beats the requirements ("the factor of labor intensiveness").

Foreign literature [99,100] was used in compiling the review on protection of information.

99. Afips Conference Proceedings, 1976, National Computer Conference, June 7-10, 1976, New York, 786 pp.

100. Protection of Information in Computer Systems. Tutorial IEEE Catalog No 75CH1050 Compcon 75. 316 pp.

Chapter 12
Problems and Methods of Determining the Economic Effectiveness of Automated Control Systems

12-1. General Remarks on the Calculation of Economic Effectiveness of ASU

Automated systems are economically effective as a result of an increase in the level of control of technological and industrial processes, enterprises, associations, sectors, agencies because of the on-line conversion of significant amount of technological and industrial and economic information, conduct of optimization calculations and simulation as well as the application of other economic and mathematical methods based on the wide use of electronic computer technology.

The economic effectiveness of automated systems is mainly expressed by the improvement of economic indicators of the control facility and also in the savings obtained in the control system. As computer technology is improved and made less expensive, the expenditures for control are both relatively (with respect to the unit of production) and absolutely reduced. One consequence of this is the expansion of economic boundaries of profitable application of ASU: they become economically profitable for smaller and smaller enterprises.

Calculations of economic effectiveness of ASU differ from calculations of economic effectiveness for introduction of individual measures of new technology. This distinction is expressed as follows:

ASU involves all basic aspects of the industrial management activity of an enterprise;

The decisive value for the economic effectiveness is an increase in product quality, reduction in production delays and an increase in product output;

Effectiveness is defined practically according to one variant and consequently the only additional capital investments are used in the calculation;

Economic effectiveness of the ASU increases in time because of the expanded range of solved problems and their assimilation;

Sources of economy from incorporation of various levels of ASU (sector, territorial, enterprise, etc.) are quite different from one another, and this requires reflection in specific methods of calculation of economy.

Thus, the general principles of determining the economic effectiveness presented in "Methods (Basic Assumptions) of Determining Economic Effectiveness of Use in the National Economy of New Technology, Inventions, and Efficiency Suggestions" affirmed by decree of the USSR State Committee on Science and Technology, USSR State Planning, USSR Academy of Sciences, and the State Committee on Inventions and Discoveries dated 14 February 1979 No. 48/16/13/3, may be used if necessary to select a version of capital investments in various measures including creation of ASU in the NIR and OKR stage.

Determination of cost accounting indicators of economic effectiveness of ASU should be done on the basis of the specifics noted above.

Economy obtained as the result of introduction of automated control systems is determined by the following factors:

Optimization of planning of production and use of resources based on the application of economic and mathematical methods;

Efficient organization of normative management including standards of operational planning and norms of reserves;

Reduction and elimination of losses of work time, materials, reduction of machine and equipment downtimes;

Fuller and timely information about the control object;

Increase in the level of analytical and organizational work of the control apparatus free from repetitive work on composition, accounting and processing of massive documents;

Rationalization of the control structure under new conditions of producing information and decision making;

Increasing the rhythmic nature of production which is a condition of economic operation in connection with elimination of losses in production.

Factors of optimized planning and operational control are basic because they yield the main part of economy from the interaction of ASU on production.

The remaining factors, while improving control, are mainly reflected in a reduction of such losses in production, which in the good organization of production and control may be eliminated without using ASU, but under the conditions of modern, dynamic production this is achieved with an increasing difficulty related also to the imperfection of information and a delay in its access.

Among these losses are the following:

Direct losses of resources (materials, working time, nonproductive expenditures including product defects, expenditures on content of equipment);

Losses from underutilization of basic productive funds;

Excess of standard level of normed floating capital (exaggeration of the volume of uncompleted products, excess material reserves and finished products).

Under conditions of ASU operation these losses can be greatly reduced, which improves the economic results of enterprise operation (there is an increase in product output and its production cost diminishes, there is an increase in debt payment, and product quality increases); in consequence, the mass of profit and profitability of production increase [196].

With the transition from enterprise ASU to higher level ASUs, the overall economy increases because the volume of resources controlled by the system increases. The main portion in the overall dimension of economy is provided by optimization of planning and economic calculations and the operational nature of control. Direct economy from a reduction in costs of solving the problems of accounting, planning and operational control in terms of the absolute level and share in the overall economy is negligible. However, profits from timeliness and completeness of information for decision making in control of a larger system with redundancy make up for the shortcoming in savings with production and processing of information.

Experience of elaboration and operation of an ASU of enterprises, associations, sectors and experience of operation of computing centers of various purpose showed rather clearly the scales of expenditures and savings. Average actual expenditures for elaboration of ASUP established by the Ministry of Instrument Construction of Automation Devices and Control Systems constituted 362,000 rubles (without capital investments). This portion of expenditures for creation of ASU--preproductive expenditures--consists of two main portions: expenditures for scientific research and planning work which in terms of the volume of expenditures are roughly equal or in a two-to-three ratio. Standardization of ASUP plans makes it possible to reduce expenditures for scientific research work to one-third and expenditures for planning and design work in half. On the whole, this relationship equals one-to-two, i.e., it tends to increase the portion of the planning work.

Planning of ASU on the whole should be done by means of the same sources as the planning of enterprises, shops and production. Expenditures for mathematical support in good organization of libraries containing subroutines for solving specific problems can be reduced to the minimum. A reduction in cost of the computer in addition to an increase in the volume of their arrangements including programming support reduces overall expenditures for creation of ASU.

From the viewpoint of the national economy, the economic effectiveness of the entire complex of ASU is determined by its structure: according to kinds of ASU and sectors of production. Savings obtained in ASU are greatest with the design of ASUTP and ASU of material and technical supply. Among the sectors where ASU also gives the greatest economic effect there are energy, chemistry, transport, construction and machine building.

Analysis of the ASU structure created in the ninth five-year plan shows that the sector structure is on the whole economically favorable (Tables 12-1 and 12-2). As concerned the type structure of ASU, it may be improved by increasing the share of ASUTP. In 1976-1980 it is planned to create about 1,300 ASUTPs instead of the 619 in 1971-1975.

On the whole, one ruble of expenditures for creation of new ASU in the ninth five-year plan in industry according to the report data of the USSR Central Statistical Administration yielded 28 kopecks in savings.

At the present time ASU of the machine construction enterprise on the average provides for an increase in labor productivity of 2.8 percent, a reduction in consumption of raw material and other materials by 1.2 percent, reduction of losses from defects by 16 percent, and a reduction in expenditures per ruble of realized product by 0.3 percent.

All calculations of economic effectiveness contain an element of indefinability which is the result of both methods problems and the need for conducting more analytical work. At the same time, this type of work is being given insufficient attention on the part of systems developers and suppliers.

The economic effectiveness to a certain extent depends on expenditures for creation of ASU. For a more precise definition of such expenditures, we should have cost standards for machine hour of computers, expenditures for programming to calculate the cost per instruction, expenditures for operation in percentages of computer cost, expenditures for solving standard problems or a set of them.

Experience in operation of computers and ASU makes it possible now to elaborate such standards in the form of limiting and average standards.

Table 12-1
Sector Structure of Complex of ASU Put Into Operation in 1971-1975 (in percents)

Sector of National Economy	Total ASU	Including system types				
		OASU and RASU	ASU of Territorial Associations	ASUP	ASUTP	Automated Data Processing Systems
Total	100	100	100	100	100	100
Industry	64	31	17	83	98	62
Including:						
Raw marerials and mining industry	39	23	16	26	84	62
Machine construction and metal working	25	8	1	57	14	--
Other sectors	36	69	83	17	2	38
Including:						
Ministries and agencies of the Union	27	34	68	13	1	35
Republic ministries and agencies	9	35	15	4	1	3

Table 12-2
Structure of Complex of ASU (by kinds of systems) Put Into Operation in 1971-1975
(in percentages of line total)

Sector of National Economy	Of Total Number of ASU				
	OASU and ASU of Republican Level	ASU of Territorial Associations	ASUP	ASUTP	Automated Data Processing Systems
Total	8	27	36	26	3
By industry	4	7	46	40	3
Including:					
Raw materials and mining	4	11	24	56	5
Machine construction and metal working	2	1	82	15	--
In other sectors	68	17	1	15	4
Including:					
Union ministries and agencies	10	67	18	1	4
Republic ministries and agencies	32	49	16	2	1

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The use of these standards would simplify the application of some methods of determining the economic effectiveness of computers and ASU and would permit a reduction of calculations to find a degree of significance of individual factors of expenditures and savings and their comparison with standard data.

Below is presented an example of calculation of the economic effectiveness of ASUP.

12-4. Economic Effectiveness of Operating ASU

As was already shown, with the accumulation of experience in designing specialized planning organizations and standardization of ASU and their parts (subsystems), expenditures for planning of ASU of all types are reduced. "Coupling" of a standard system or subsystem to a similar object requires much less means than a new ASU project.

According to the data of ministries and agencies in machine construction for 1976, one-time expenditures for elaboration and introduction of a single ASU by a large enterprise averaged 1,250,000 rubles, including 300-350,000 rubles for pre-industrial expenditures for development of the ASU project and computer programs. The cost of hardware for data conversion generally runs from 900,000 to 1,000,000 rubles; expenditures for construction or reconstruction of buildings to house the computer center does not exceed 80,000 to 100,000 rubles. One-time expenditures for a single subsystem run from 200,000 to 240,000 rubles and per task run from 25,000 to 30,000 rubles.

Expenditures for operation of the ASU in machine construction do not exceed 250,000 to 400,000 rubles. With an increase in the volume of production, the relative significance of operating expenditures will be reduced because of development of the system as well as the resolution of more complex problems and an increase in their number.

The annual increase in profits per system is 500,000 to 1,000,000 rubles including: because of increased volume of products, 170,000-340,000 rubles and because of reduced production costs 330,000 to 660,000 rubles or, respectively, from 34 to 66 percent.

Knowledge of some of the quantities characterizing change in the enterprise operating indicators after introduction of ASU bear witness to the real effectiveness of introducing the systems: for example, a reduction of introshift losses of work time for organizational and technical reasons reaches 40 to 45 percent; a reduction in the consumption of raw materials and other materials, 1 to 3 percent; a reduction in overtime pay of 15 percent; a reduction of defect losses 6 to 16 percent; a reduction in nonproductive expenditures of 10 to 15 percent; a reduction of expenditures per ruble of product manufactured 0.5 to 0.6 percent.

In the ASU of the Kamsk Association for production of large cargo vehicles (ASU-KamAZ) of the Ministry of the Automobile Industry adopted in December

1976 by the Interagency Commission, a complex of problems is solved on accounting for the flow of production encompassing 45 shops and 50 warehouses containing over 8,000 subassembly units and parts.

The economic effect of introducing the first phase of ASU-KamAZ is 3,950,000 rubles with a payback period of 1.3 years.

The scientific and technical level of the system is mark 8.3. In 1976 an ASU was created for preparation of raw material mixtures in the first process line of the Novo-Karagandinsk Cement Plant. The system contains an M-6000 process control computer and with capital expenditures in the system of 665,000 rubles the annual economic effect is 200,000 rubles. When this system was introduced, furnace productivity increased 0.5 percent, clinker grade improved (by 5 to 7 units), expenditures for lining the furnaces were reduced by increasing its stability by 7 percent, and the relative consumption of fuel was reduced by 1.5 percent.

ASU of ore mining processes in the underground mine "Komsomol'skiy" of the Noril'sk mining and metallurgical combine contains an M-6000 process control computer and TM-300 telemechanical device. With expenditures for the system of 1,500,000 rubles, the economic effect of the startup complex will provide a payback period of expenditures within the established norm. The automated system of the conveyor for horizontal extraction of tubing in the Saransk Industrial Association "Svetotekhnika" with expenditures of 250,000 rubles provided an annual economic effect of 500,000 rubles by reducing product defects by 3 percent, reducing operating defects nearly to one-half. In 1976 at the concentration factory of the Zyryanovsk Lead Combine an ASU was introduced which assured an increase in metal extraction of 3.46 percent, an increase in extraction of associated metals of up to 85.5 percent, reduction in operating and service personnel in dangerous production and laboratories of 232 men. On the whole, throughout this system with overall expenditures of 4,500,000 rubles, the annual economic effect was 3,700,000 rubles. At the Cerepovetskiy Chemical Plant a system was introduced for production of sulfuric acid. This system has an M-6000 process control computer. With overall expenditures of 700,000 rubles, the annual economic effect from introducing this system came to 430,000 rubles, 380,000 rubles of which was due to reduced production cost and 50,000 rubles was due to increased variety and reduced wages.

At the Kharkov Motor Construction Plant "Hammer and Sickle" expenditures for introduction of this system came to about 2,500,000 rubles and additional profit obtained from the increase in product output exceeded 600,000 rubles, and from reduction of product cost 1,040,000 rubles. The primary factors of savings were: reduced expenditures for wages 398,000 rubles and reduced consumption of materials 60,000 rubles. The ASU of the Odessa Plant of Agricultural Machine Construction imeni October Revolution with expenditures of 1,290,000 rubles provided an additional profit amounting to 630,000 rubles, including: 147,000 rubles due to reduced consumption of materials, 127,000 rubles economy in wages, 40,000 rubles from reduced defect losses, and 11,000 rubles from reduced nonproductive expenditures.

Three-fourths of the operating ASU yield an economic effect of up to 600,000 rubles each. At remaining enterprises the annual economic effect ranges from 700,000 rubles to 1,500,000 rubles or more. Among the latter are: the Orlovsk Plant "Khimtekstil'mash" (Minlegpishchemash), the Kramatorskiy Plant of Heavy Machine Construction (Minstankoprom), the Kiev Plant "Krasnyy Ekskavator" (Minstroydormash), the Yaroslavsk Association for Production of Automobile Diesel Motors (Minavtoprom), the Novo-Kramatorskiy Machine Construction Plant imeni V. I. Lenin (Mintyazhmash), the Kharkov Plant "Elektrotyazhmash" imeni V. I. Lenin (Minelektrotekhprom), etc.

Analysis of expenditures for elaboration of sector automated control systems (OASU) showed that on the average expenditures per system come to slightly more than 4,000,000 rubles. The payback period of expenditures for establishing OASU in most ministries and agencies ranges from one to three years, including one to two years in Minstroydormash, Min-Minpishcheprom USSR, Minkhimmash, Minkhimprom, Minnefteprom; in five ministries the payback period is less than a year (Minavtoprom, Minlegpishchemash, Minpribor, Minsel'khozmash); in five ministries it is two to three years (Minbumprom, Glavmikrobioprom, Minlesprom USSR, Minmyasomolprom USSR, Minstankoprom). Introduction of OASU makes it possible to solve a wide range of problems related to improved operation of assets and debt payments, and the use of labor and financial resources.

A considerably greater effect is yielded by OASU in industry, in whose sphere of activity there are larger resources.

In Minpishcheprom in the ninth five-year plan work was completed on creating sector automated systems of control for twelve ministries of Union republics. By now in the food industry there are in operation the first phases of two systems: OASU--Ukrpishcheprom and OASU--Molpishcheprom, etc. Work on automation of sector management in Minpishcheprom is being done simultaneously with work on creation of ASUP. The total for creation of ASU of various purposes in the food industry expended in 1971-1975 came to about 49,000,000 rubles, for capital investments including acquisition of computers 26,500,000 rubles, including 20,500,000 rubles for NIR.

The theoretical economic effect from introducting automated management systems comes to about 33,000,000 rubles, the payback period of expenditures is at least three years.

In Minstroydormash an OASU has been developed and put into operation to handle ten subsystems and 169 tasks including the distribution of tasks to subsystems as follows:

Technical and economic planning	9
Operational control	9
Control of material and technical supply	25
Bookkeeping	26
Management of financial activity	19

Planning, accounting and analysis of labor and wages	27
Management of planning of capital construction	32
Specific subsystems	32

Expenditures for elaboration of the first phase of the OASU of Minstroydormash came to 850,000 rubles and for capital investments 950,000 rubles, while the annual economic effect according to ministry calculations comes to 2,600,000 rubles.

Republic systems elaborated by organizations of Minpribor (Minlegprom BSSR, Minlegprom Uzbek SSR, Minpishcheprom BSSR, Minpishcheprom Uzbek SSR) have a rather high scientific and technical level.

In the OASU of Minlegprom BSSR there are six subsystems which tackle 78 tasks; in a similar system of the ministry of the Uzbek SSR there are eight subsystems covering 31 problems; in Minpishcheprom BSSR and Uzbek SSSR there are six and ten subsystems, respectively, handling 46 and 54 problems.

The standard subsystems introduced by republic ministries come to more than 95 percent of the overall number of subsystems. The grade of relative significance is shown by problems of bookkeeping (20 percent); operational management (19 percent); management of material and technical supply (15 percent); technical and economic planning (10 percent), i.e., about 60 percent of the total number handle these problems.

In certain advanced systems there is an increase in the tasks of planning and analytical nature. Thus, in the OASU of Legprom BSSR planning problems (including planning and optimization) constitute 14 percent, problems of analysis 35 percent, and problems of accounting and control 51 percent.

The basic economic indicators of OASU of republic ministries in the industrial sphere are shown in Table 12-4.

The ASU of Minzhilkomkhoz RSFSR in the Sverdlovskaya and Chelyabinskaya oblasts are being effectively utilized. The ASU of the Sverdlovskaya oblast was introduced as part of five subsystems and 107 tasks. Expenditures for the system came to about 2,500,000 rubles, annual economic effect of 1,500,000 rubles, payback period of 1.3 years. The ASU of the Chelyabinskaya oblast was introduced among five subsystems which tackle 66 problems. The annual economic effect is 716,000 rubles, expenditures for creation and introduction of the system 1,280,000 rubles, payback period 1.3 years.

The sector automated system in Minmestprom of the Estonian SSR was introduced in 1976, and the expenditures for its creation came to 1,350,000 rubles; theoretical economy of 600,000 rubles, with a payback period of about two years.

Table 12-4

Ministries	Expenditures for System			Annual growth (thou. rubles)	Annual Savings (thou. rubles)	Payback Period (yrs)
	Total	NIR/OKR	Capital invest-ments			
Minlegprom BSSR	2,435	1,100	1,335	1,172	807	2.1
Minlegprom UzSSR	5,065	600	4,465	5,960	5,200	0.8
Minpishcheprom BSSR	1,363	725	638	795	590	1.7
Minpishcheprom UzSSR	1,300	800	500	595	400	2.2

Naturally, not all ASUs are economically effective. But this is not the fault of the computer but the result of unwise application. The guilty parties are the organizations which have not established all the conditions for using computer technology and economic and mathematical methods.

Introduction of ASU is not always accompanied by a change in the structure and a reduction in the number of management personnel, although tendencies in this direction are completely defined.

In the system of the Ministry of Construction of Enterprises of Heavy Industry of the Kazakh SSR, ASU of centralized transports of solution and concrete introduced at twenty associations have made it possible to free 344 workers, reduce downtime at construction facilities by an average of 5.5 percent by improving utilization of automated transport to free 175 vehicles. The economic effect from introduction of this system came to about 2,000,000 rubles.

In the Ministry of the Coal Industry of the Ukrainian SSR, the establishment of sections for centralized collection and output of reports made it possible to reduce the number of personnel employed in accounting work, in the ministry from 70 to 50 persons, in the industrial association from 612 to 244 persons.

Introduction of problems of automated calculation and requirement applications of agriculture for spare parts for tractors, automobiles, agricultural machines at Soyuzsel'khoztekhnika made it possible to free more than 4,000 experts, greatly accelerate the formation of more accurate orders for industry.

In several ministries steps were taken to improve the management system by more complete centralization of major industrial functions. This work was done in automobile transport, which made it possible for some ministries of the Union republics to shift the sector from a four- or five-link structure to a two- or three-link structure of management. As a result of the complex of measures to improve management of the sector in Minavtotransport BSSR instead of 171 cost accounting associations, there were 19 large associations, administrations and combines; labor productivity in the ministry increased 29.5 percent, and the cost of transshipments decreased by 9 percent.

The primary thing was a reduction in the number of administrative personnel which signifies a reduction in administrative expenditures per ruble of product.

The most general factor which retards the process of ASU creation is the lack of the necessary number of qualified developers, with a particular lack of economists and problem analyzers and mathematical programmers.

The concentration of personnel in large organizations for programming support of computers and their service is necessary.

Shortcomings in programming support, in configuration of ASU with both computers and peripheral equipment reduce the useful operating time of the computer, and lengthen the periods of time required to present processed information to administrative personnel.

As was already noted, one of the most substantial shortcomings is inadequate study of formalization (algorighmization) of management problems; the search for new problems in management which cannot be resolved without computer is also being poorly conducted.

With the shift from enterprise ASU to higher level ASU, the overall economy increases since the volume of resources controlled by the system increases. But the first place in the overall dimension of savings belongs to optimization of planning and economic calculations. Direct savings from reduced cost of solving accounting problems, planning and operational administration controls in terms of the absolute level and share in overall economy is negligible. However, the profit from timely and complete information for decision making in management of a larger system make up for the shortcoming in savings in production and processing of information.

The accelerated saturation of the national economy with computers is leading to a temporary reduction in the overall load of their number. It also creates a low productivity structure for loading because of the considerable amount of work for the system itself and for mastery of calculations on the computer by service personnel. This situation was particularly typical for the ninth five-year plan [58]. Consequently, since January 1, 1977, temporary tariffs per hour of computer operation have been established. This will make it possible to strengthen the cost accounting interest of independent computing centers as well as computing centers of enterprises and organizations in the better utilization of computers, in reducing costs per hour of computer operation, in reducing operating expenditures, as well as in strengthening stimuli to rent out unused computer time.

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COLLECTIVE-USE COMPUTER CENTERS

Moscow VYCHISLITEL'NYYE TSENTRY KOLLEKTIVNOGO POL'ZOVANIYA in Russian 1979 signed to press 4 Apr 79 pp 3-6, 269-271

[Introduction and table of contents from book "Collective-Use Computer Centers," edited by V. I. Maksimenko and Yu. A. Mikheyeva, Izdatel'stvo "Statistika," 10,000 copies]

[Text] The development of computer engineering has taken place in our country in a number of stages. Initially (from 1954 to approximately 1965) the computers were at the disposal of individual organizations, and they were used primarily for the purposes of these organizations. The enterprises not having their own computers at their disposal almost had no access to the computer.

In 1965 to 1970, the sale of machine time, leasing and other forms of joint operation of computers was widespread. After 1970 the collective-use of computers became widespread: the creation of multi-user computer centers and then collective-use computer centers began. The design operations with respect to combining the computer centers into a state network (GSVTs) began.

The areas of application of computer engineering are expanding constantly. Whereas computers were initially used in only a few branches of industry to facilitate calculation and accleration of the engineering calculations, they are now used everywhere to solve a broad range of problems. Today 375 classes of problems in 60 branches are solved by computer in the Soviet Union, whereas 5 years ago computers solved problems in only 50 classes, and they were used in only 7 branches.

However, the rush of each enterprise and institution to have its own computer has led and often still leads to the scattering of computer engineering means and reduced loading of the computers, duplication of design work and the work of creating the software. With this approach the possibilities for automation of control at numerous small and medium enterprises have been sharply limited.

A real alternative to the present approach is combination of the collective and individual-use computers within the framework and on the basis of the National Automated Data Gathering and Processing System for Calculation, Planning and Control (OGAS) and its technical bases, the GSVTs [State Network of Computer Centers] and the OGSPD [Statewide Network for Data Transmission] created in the Soviet Union.

The goal of the OGAS consists in combining all of the automated control systems (from the automated production control systems to the systems for controlling central functional agencies) and at the same time insuring effective interaction of the national economic control agency on all levels when solving problems of accounting, planning and control. It is essentially important that the automated systems of all control levels, interacting within the framework of the OGAS, will insure the solution of problems of an interdepartmental nature.

The basic elements of the GSVTs are the collective-use computer centers. In the GSVTs it is proposed that 200 basic VTsKP* be created, the introduction of which into operation will be accomplished in stages. In this five-year plan seven of the VTsKP are being built in the first phase. The principles of using series hardware and software, the creation of information support, the legal and organizational problems and also problems of intercommunications of the VTsKP with the subscribers must be worked out in these centers.

What are the most important advantages of the collective use computer in control? Above all, the organizational, technical and procedural unity of the automated control systems created for the subscribers will fully permit the use of the advantages of the socialist system for control and achievement of scientific and technical progress. The all around use of computer engineering means will make it possible to increase the computer load, lower the expenditures on acquiring technical means, and the broad application of high-output computers will make it also possible to lower the specific cost of data processing. There will be a possibility of automating the design of the systems, accelerating the design developments, centrally introducing standard design solutions. The broad circulation of the software will permit the expenditures on automated control systems to be reduced, insurance of effective use of the united All-Union Library of Algorithms and Programs, the equipment and operation of the computer centers as a result of using standard designs.

As is known, the automated systems have been introduced up to now only at large enterprises with satisfactory conditions for the effective utilization of computers. With the expansion of the scales of application of computers and the appearance of large and superlarge computers, the possibilities for extensive introduction of computer engineering in the USSR are limited, and this path will become inexpedient.

When maintaining the existing approach, as design experience shows, it is impossible in any way significantly to raise the level of effectiveness of the automated control systems, there are fewer possibilities for automating the basic control functions on all levels of the national economy.

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*[Collective-Use Computer Centers]

It is necessary to consider that in our country there are about 580,000 enterprises, organizations and institutions isolated for independent budgeting. They include more than 4.6 million different subdivisions, the basic information and control functions of which are subject to automation. It is possible to solve the problem of automation on such enormous scales only on the basis of creating the GSVTs.

One of the most important and obvious advantages of the VTsKP is a significant reduction in the one-time capital expenditures on developing the automated control system and the current expenditures on operation and maintenance of them and also a sharp increase in technical-economic operating indices of the enterprises, organizations and institutions.

The specific expenditures on developing control systems for which it is possible widely to disseminate the practice of standard planning and design are dropping especially quickly when creating the VTsKP.

On the whole, the creation of the first phase VTsKP must become the source of accumulation of experience, on the basis of which the mass creation of the KVTs [Multiple-User Computer Centers] and the VTsKP begins. The development and introduction of the VTsKP into operation constitute the most complex problem, the solution of which is being worked on by scientists, designers, control workers, engineers, mathematicians and economists. The given collection is also devoted to the exchange of experience with respect to the design and creation of various elements of the VTsKP.

The collection is made up of three sections. In the first section a study is made of the problems of the development of the principles of designing the VTsKP as an independent object: the problems of determining the overall technical requirements on the VTsKP, the development of methods of designing the VTsKP and the subscriber network and also the general problems of creating the VTsKP.

In the second section are articles about the experience of the planning and design of the specific first-phase VTsKP and the control systems created on the basis of them. The third section is devoted to the development of individual elements of the software, information support and hardware.

This collection is one of the first in a series of books on the problems of the development, operation and maintenance of the VTsKP, the creation of a subscriber network and automated subscriber control system. The problems of effective functioning of the computer complexes, the use of the various simulation hardware and many others will find reflection in subsequent publications.

D. G. Zhimerin, corresponding
member of the USSR Academy of
Sciences

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The articles in this collection, which were prepared by specialists of the leading organizations and enterprises of the country, familiarize the readers with the basic problems of planning, design and introduction of the collective-use computer centers (VTsKP). In the collection a study is made of the organizational and legal problems of creating the VTsKP, their hardware, software and information support and also the experience in the operation of such systems and the services provided by them.

The collection is designed for specialists working with the practical introduction and use of computers in various areas of the national economy.

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DESIGNING COLLECTIVE-USE COMPUTER CENTERS

Moscow VYCHISLITEL'NYYE TSENTRY KOLLEKTIVNOGO POL'ZOVANIYA in Russian 1979 signed to press 4 Apr 79 pp 7-78

[Article by V. N. Kvasnitskiy, V. I. Maksimenko]

[Excerpts]

Category of collective-use computer centers	Output capacity, millions of operations/sec
5	0.3-0.5
4	0.5-4.5
3	4.5-12.5
2	12.5-25.0
1	25.0-50.0

Hardware Requirements. The VTsKP hardware can include the complexes and devices produced in series or prepared for series production (in the presence of developed design documentation).

The VTsKP computer system must be built as a multimachine complex based on the YeS-1033, YeS-1035, YeS-1040, YeS-1045, YeS-1050, YeS-1060 computers. As the dispatch computers, it is possible to use the YeS-1010, YeS-1015, YeS-1022, M-6000, M-7000 and the SM-3. For the organization of a subscriber network, the minicomputers, group control media with displays, the remote processing equipment of the unified system of computers (YeS-EVM), the data transmission equipment, the Iskra-126 type intellectual terminals and the kit products can be used.

The combination of the computers into a multimachine complex must not have a negative effect on the basic characteristics of these computers (output capacity, memory size, number of communication channels connected and peripheral equipment) by comparison with those indicated in the certificates.

The VTsKP hardware must provide for the creation of a common memory field on magnetic discs and tapes.

The remote processing means of the VTsKP are designed for connecting the subscribers using the terminal equipment (the subscriber stations of the YeS EVM, the programmed subscriber stations (AP), the concentrators based on the minicomputers, and so on) located both at remote and local subscriber stations. For the hardware providing for the interaction of the computers in a complex through a channel-channel adapter, the possibility of coupling through these means to the ASVT, SM EVM and other models must be provided.

The connection of a set of devices for controlling the peripheral equipment to the computer must satisfy the requirements of the standards: "Input-output interface. Structure and composition. Requirements on functional characteristics" and "Input-output interface. Parameters and structural designs of the electrical connections."

The electric power supply for the devices in this set must come from the industrial three-phase, 380/220 volt, AC network with deviation from +10 to -15% and a frequency of 50±1 hertz. The complex hardware must provide for centralized connection and disconnection of the computer power and devices.

The ZIP [spare parts and tools] kits and the service equipment of the VTsKP must be determined considering the possibility of autonomous technical servicing, and the ZIP and service equipment set for the hardware of the user subscriber stations, considering their centralized technical servicing.

The set of technical means of the VTsKP must include the devices for preparing the data on punch cards, punch tape and magnetic tape, the bays for storing documents, magnetic carriers and punch carriers, the devices for transporting the technical information carriers, and also equipment for reproduction and formatting the output documents.

Requirements on the Data Transmission Equipment and Communications Media. The data transmission equipment of the VTsKP and the subscribers must provide for the following:

Duplex and half duplex data exchange modes;

Possibility of automatic establishment and breaking of connections;

Reliability control of the information;

Error probability during data transmission of no more than 10^{-6} per character;

Data transmission rate: 50-200, 600-1200 and 600-4800 bits/sec over the switchable and segregated telegraph and telephone cables, respectively.

The five-element MTK-2 code and the eight-element code according to All-Union State Standard 19768-74 can be used for data transmission.

The coupling of the data transmission equipment to the communications channels must be accomplished in accordance with the requirements of the standards at the C_2 junction: OST4GO.208.004, OST4GO.208.005, OST4GO.208.000; with the terminal data equipment, All-Union State Standard 18145-72, for the C_2 junction and All-Union State Standard 18146-72 for the C_3 junction.

Requirements on the Hardware of the Subscriber Stations. The hardware and software of the subscriber stations are designed for the following operations:

Preparation of the information for the technical carriers (punch tapes, punch cards, magnetic tapes);

Information input and output for the VTsKP computer system in the modes.

The number and types of subscriber stations are determined in accordance with the volumes of operations of the subscribers and the regulation of the solution of their problems. Here it is necessary to consider the possibility of creating group subscriber stations for several subscribers located close together.

Requirements on Systems Software. The operating system of the VTsKP in the first phase must make maximum use of the possibilities of the operating systems beginning with the OS-4.0 version and include the following components:

The software of the computer complexing means;

The planning subsystem (KROS);

The collective-use dispatcher (DKP);

The subsystem for dialog remote input of assignments (DUVZ);

The Kama remote data processing system;

The Oka data base control system.

Each of the subsystems must include the program components and documents, including the description of the subsystem, the operating instructions, and the means of generating the subsystem.

The operating system of the first phase of the VTsKP must insure the following possibilities for the intermachine information exchange:

Through the common field of the external memory based on magnetic tapes and/or magnetic discs;

Through the channel-channel operators;

Through the direct control media.

The KROS subsystem realizes the following functions:

Planning and starting the system input program and the system output program;

Establishment of the priority of execution of the assignments of the input flow;

Dynamic ordering of the problems based on the consideration of the use of the central processor and the input-output devices;

Automated inclusion of the assignments generated by the users performing the assignments in the input flow;

Transmission of part of the input flow to the corresponding processing program, bypassing the planner of the OS YeS*operating system;

Dynamic distribution of the external memory required to buffer the input and output data files;

Exclusion of the redundancy functions from the OS YeS operating systems.

The application of the KROS must not introduce any changes in the OS YeS.

Reliability Requirements . In the first and second stages of creating the VTsKP, the reliability indexes of each of the devices must correspond to the technical specifications for these devices. The computer complex must provide for continuous around the clock operations with the following reliability parameters:

The time worked per failure T_0 of the hardware no less than 2500 hours;

Average repair time T_B with autonomous servicing, no more than 0.5 hours;

Technical use coefficient $K_{T.I}$ no less than 0.95.

The reliability parameters are determined when solving problems which load no more than half the like devices entering into the tested complex.

By a failure of a two-machine computer complex we mean the condition in which it loses the capability of solving problems. The switching of the device used to solve the given problem to another, like device is not taken as a failure of the complex.

*Operating system of the unified system of computers

The time for readying the computer system together with switching on the power must not exceed 0.5 hours. The computer system of the VTsKP computer center must provide for storing the information if there is an emergency power failure. The VTsKP hardware must have a ZIP [spare parts kit] calculated to insure around the clock operation and maintenance considering the preventive measures with autonomous servicing for 10,000 hours. When performing preventive maintenance and repairs, switching the power on and off on individual devices and groups of devices, the operation of the functioning devices must not be interfered with.

Requirements on the Complex Protection of Information at the VTsKP. For complex protection of information at the VTsKP it is necessary to provide means, methods and measures insuring constant reliable protection of the information stored and processed at the computer center, on the part of its integralness in the transmission, processing and storage processes and also prevention of unsanctioned access and use of the information.

The information protection must be insured for various processing modes at the VTsKP: package with the formation of a package of assignment both by the computer center operators and users; time sharing; single-program; multiprogram, and so on.

The information protection must be set up beginning with the proposition that the following categories of users will interact (directly or by means of the computer center operators) with the VTsKP computers in the general case:

The control personnel of the VTsKP subscriber organization;

Programmer;

The data bank administration.

The protection at the VTsKP computer center is provided for the data and program files. The protection of the integralness of the information from the following factors is provided:

Human errors;

Equipment failures;

Program errors;

Destruction or negative effects on the characteristics of the carrier during storage;

Elemental disasters (earthquakes, fires);

Sabotage.

The solution of the following protection problems must be provided for:

Insurance of conditions for preserving the information;

Monitoring the integralness of the information;

Localization of a violation of the integralness of the information;

Restoration of the integralness of the information after violations.

The set of protection problems solved at the VTsKP provides for monitoring of the integralness of the information:

In the process of setup and the terminal and other remote devices;

In the process of data preparation at the UPD [interfaces];

Transmitted over the communication lines;

Processed on the computer;

Stored in the external memories and in the libraries.

When using the protection problems the integralness of the information is restored after the following factors:

Detection of setup errors at the terminal;

Detection of punch errors;

Distortions in the communication lines;

Failures in the central computer;

Distortions in the external memory;

Damage to the carrier;

Elemental disasters;

Sabotage.

The following protection must be insured by solving the problems with respect to covering the potential information leakage channels:

From misappropriation of the carriers and documents;

From memorizing or copying the information;

From unsanctioned connection to equipment;

From adaptation of the software;

From picking up the electromagnetic radiation.

For reliable coverage of the enumerated channels the VTsKP must provide for the solution of the following groups of problems for preventing unsanctioned use of information:

Prevention of access to the VTsKP facility by outside people;

Limiting the access of users and problems to the protected files;

Localization of unsanctioned access;

Exclusion of indirect information leakage.

The limiting of the user and problem access to the protected files provides for the following:

Unsanctioned access of the users to the data (the memory fields);

Unsanctioned action by the users;

Access of problems to the data beyond the limits of the provided addresses;

Recording all acceses to the protected data.

The problems of localizing and unsanctioned access provide for the following:

Additional coverage of information having a security classification;

Signalling an effort of unsanctioned access to the protected information;

Erasure of protected information in memory after solving problems;

Emergency destruction of the protection information in case of efforts at unsanctioned use of it.

The problems of the prevention of incorrect information leakage provide for the following:

Exclusion of leakage of protected information through electromagnetic radiation;

Exclusion of information leakage through production waste.

Building and Facility Requirements. When installing the equipment, the admissible loads on the floors of the building must correspond to the following requirements, kg/m^2:

Machine room	1000
Data preparation room	500
Basic paper information carrier storage	2000
Paper carrier archives	1000
Magnetic information carrier storage archives	2000
Facility for central air conditioning equipment	2000
Facility for service equipment and reproduction machines	500
Facility for power engineering equipment	2000
Technical service facility	500

For the machine rooms it is necessary to use one and two-story facilities; for the basic paper information carrier storage, power engineering equipment and central air conditioning equipment facilities in the basement and half-basement are used.

The area at the VTsKP computer center set aside for the facilities designed for service and administrative personnel must be calculated beginning with the standard of 3.5 m^2/man. The production volume of the facilities per worker must be no less than 15 m^3.

The area of the auxiliary facilities is as follows: workshops, storage, archives, corridors, stairwells and so on must be no more than 25 to 30% of the total area of the VTsKP.

The VTsKP machine rooms are equipped with a process flooring (false floor). When installing the false floor in the machine rooms at the VTsKP the following must be provided for:

Free space from the supporting structures (floor plates) 450 to 500 mm;

Technical concentrated load no less than 40 kg/cm^2 and distributed load to 1000 kg/m^2;

Installation of horizontal partitions inside the flooring space for organizing air distributing sections and zones for supplying air conditioned air to the equipment;

Installing power and communication cables under them;

Installing elements of the fire extinguishing systems;

Installing blackout systems;

It is necessary to have no less than 0.75 hour fireproofness rating.

The VTsKP building must correspond to the requirements of second degree fireproofness and the explosion-hazard requirements corresponding to the "normal" class, and it must have no less than two evacuation exits.

The climatic conditions for the operation and maintenance of the hardware and information storage must be as follows:

Ambient temperature, °C, $t=20\pm5$ (optimal temperature, °C, $t=22\pm2$°C);

Relative humidity, %, $\phi=\phi=65\pm15$;

(Optimal relative humidity, %, $\phi=52\pm7$%);

Atmospheric pressure, mm Hg from 630 to 800.

The air conditioning system must provide an excess air pressure in the machine room of 1 to 1.5 mm Hg.

The dust content of the air must not exceed, mg/m^3:

In the machine room facilities	0.3;
In the machine carrier storage	1;
In the magnetic carrier storage	0.3;

The dust particle size must be no more than 3 microns.

The general illumination of the VTsKP machine room facility with combined lighting must be 750 lux at the height of 0.8 meters from the floor level. The general illumination of the other facilities of the VTsKP where the equipment is stored and service personnel are located must not be less than 400 lux.

The electric power supply system for the VTsKP building is arranged by groups:

Separately for the electronic hardware of the VTsKP;

Separately for the lighting and fire extinguishing systems.

The fluctuations in the AC voltage must not exceed $\pm$10-15% of the normal value and $\pm$1 hertz with respect to frequency.

The admissible noise level in the production facilities of the VTsKP center must not exceed:

75 dbA in the machine room with the data preparation and input-output devices installed in it;

65 dbA in the facilities with the VTsKP service personnel;

85 dbA in the power engineering equipment facilities;

65 dbA in the archives.

The machine rooms and other production facilities are equipped with automatic fire signals and protection providing for volumetric gas fire extinguishing in the process floor space, the suspended ceiling and the facilities themselves. In the ventilation and air conditioning systems it is necessary to provide for structural measures that will decrease the fire hazard.

The air cooling conditioning systems for the entire VTsKP building must be the separate type, separate for the machine rooms and separate for the facilities for the archives, the servicing units and the service facilities of the VTsKP.

The basic technical solution with respect to the set of technical means, the systems of software, the structure of the subscriber network, the network functioning regimes and algorithms, the structure and principles of the organization of the automated data bank, the composition of the information libraries, the data processing technology, and so on. The technical design phase does not have significant differences from the methods and rules used when designing the local computer centers.

The operating design includes the following: the development of the operating design; installation and startup of the computer systems; checkout of the basic functioning regimes; the creation and testing of the subscriber network; the development and adaptation of the subscriber programs and the experimental checkout of their fitness,and so on.

The composition of the operating design of the VTsKP is determined by the procedural guidance material STD-01.005 RMM, red. 1-77.

The operating design documentation for phase I of the VTsKP has been set up in accordance with the general principles and requirements of the unified systems of design documentation (YeSKD), the unified system of program documentation (YeSPD) and also the norms and rules for the other normative-technical documentation systems in effect in the organizations that design VTsKP.

The basic documentation with respect to the VTsKP is approved by the organization to which the VTsKP is directly subordinate. As a rule, the operating design contains several standard sections.

The operating design list is compiled analogously to the specifications list with respect to All-Union State Standard 2.106-68 "Basic Principles" and contains a list of all sets of documents. The document set is recorded by the basic document, and the component parts are not enumerated. The entry is made in the following sequence: original documentation (developed for the given design), documentation borrowed from other developments, documentation from the standard document system.

In the "Rules on Collective-Use Computer Centers" (or the temporary rules) the principles are set down for creating the VTsKP, the subordination of them, the groups of serviced subscribers, the staff-organizational structure, the order of development, the fixed and circulating capital. The basic functions and missions of the VTsKP are enumerated, the principles of the cost accounting activity of the center after it is put into industrial operation are established, the order of attachment of subscribers and their interrelation to the VTsKP, the responsibility of the VTsKP for quality and timeliness of service rendered the subscribers are defined.

The rules on VTsKP are approved by the superior organization administering the VTsKP, and they are agreed on with the GKNT.

The list of permanent subscribers must contain the following: the full name of all subscribers with indication of location, time (year, month) of connection to the VTsKP, number of workers in the subscriber organization, volume of information computation operations, forms of communication with the VTsKP for each subscriber. The summary list of permanent subscribers is approved by the superior organization administering the VTsKP.

The operating design of the communications network of the VTsKP contains the necessary information on the subscriber network of the VTsKP, the composition and connection of the communications equipment, the characteristics of the communications channels, the installation of technical communications media and the insurance of normal operation of them. The design is executed by specialized organizations of the communications ministry (Giprosvyaz') and is proved by the VTsKP management.

The standard documentation system of the VTsKP is designed for use in the working designs of the VTsKP permitting the nomenclature of the original documents to be reduced, the operating designs of the VTsKP to be standardized, the time to be reduced and the quality improved for the development of the working documentation.

The classification of the STD [standard documentation system] is as follows:

General rules 01.000;

Legal support 02.000;

Organizational support 03.000;

Economic support 04.000;

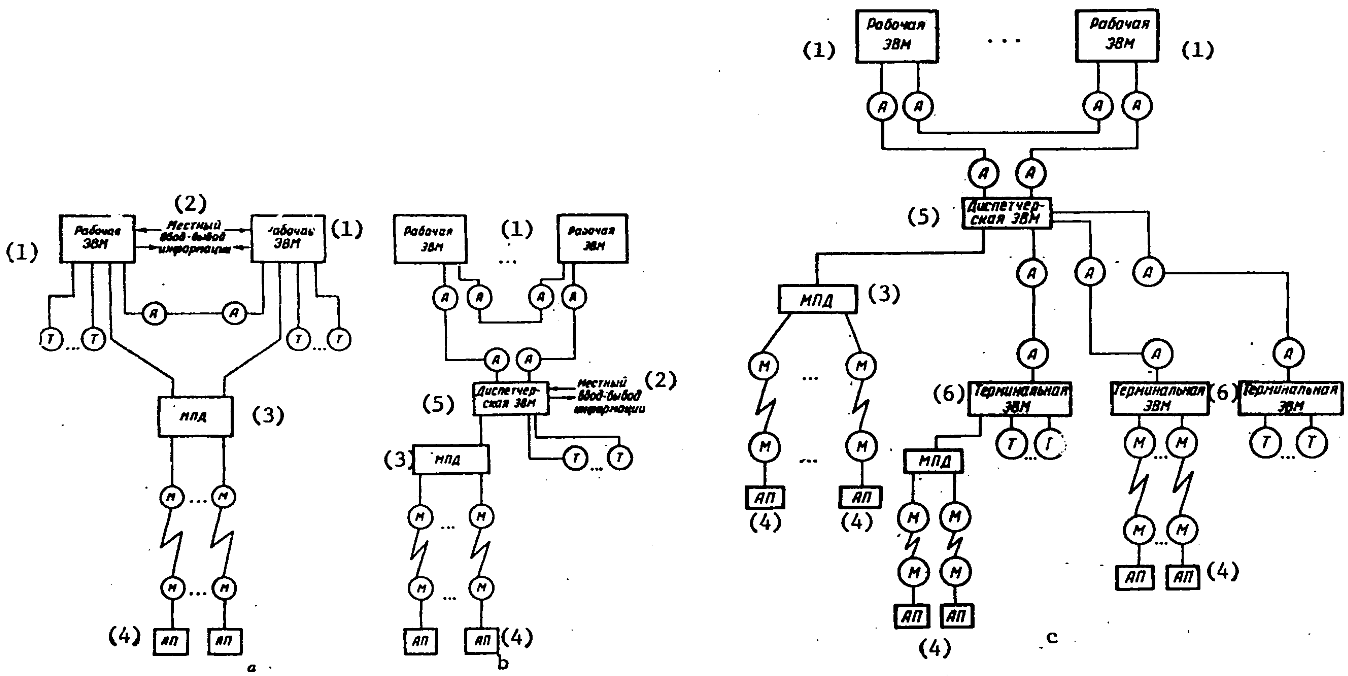

Figure 4. Types of computer systems recommended for the VTsKP: single-level (a), two-level (b), three-level (c)

Key:
1. Operating computer
2. Local information input-output
3. MPD - multiplexors for data transmission
4. AP -- subscriber station
5. Dispatch computer
6. Terminal computer

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Problems and evaluation of the volumes of information-computation operations 05.000;

Hardware 06.000;

Organization of the subscriber network 07.000;

Information support 08.000;

Software 09.000;

Information processing technology 10.000;

Technical-economic planning, counting and reporting 11.000;

Subscriber computer center 12.000;

Methods of information protection 13.000;

Organization of user training 14.000.

[389-10845]

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STANDARDIZATION OF THE PLANNING AND DESIGN SOLUTIONS FOR VARIOUS CATEGORIES OF COMPUTER CENTERS

Moscow VYCHISLITEL'NYYE TSENTRY KOLLEKTIVNOGO POL'ZOVANIYA in Russian 1979 signed to press 4 Apr 79 pp 78-93

[Article by G. V. Reznikov]

[Excerpts] One of the most important problems in the planning and design of computer centers is the creation of the dispatch centers of the engineering systems and equipment (SDISOB) which insure fitness of the hardware (TS) of the computer center during its operation. The engineering systems include the following: the cooling and air conditioning systems of the computer center TS, electric power supply, fire extinguishing and signal systems, the systems for the emergency state of the TS. This arises from the fact that the modern computer centers and collective-use centers, for example, of high categories, occupy significant areas (to 16,000-18,000 m^2); they require a large amount of electric power (to 1200-2000 kilowatts) and they have various technical means with specific operating characteristics.

All of this gives rise to the necessity for having various services at the computer center which up to now have not encompassed a unified system for operations planning, monitoring and automated checkout of the various hardware and control of it. For example, the YeS-1065 and the El'brus MVK computer systems proposed for application at the VTsKP computer centers, categories I and II, include a highly complicated complex of process equipment for cooling and electric power, the maintenance of which without dispatching their operation is difficult. Therefore the necessity for creating the SDISOB is an urgent problem when designing the computer center.

[389-10845]

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ANALYSIS OF THE VTsKP SUBSCRIBERS AND THEIR PROBLEMS

Moscow VYCHISLITEL'NYYE TSENTRY KOLLEKTIVNOGO POL'ZOVANIYA in Russian 1979 signed to press 4 Apr 79 pp 94-102

[Article by Yu. V. Sychevskiy]

[Text] The collective-use computer systems have been built in cities, the krays, oblasts, the autonomous and union republics of the country for providing the information-computer services to any subscriber in a given territory independently of its departmental subordination.

Soviet, party and public control agencies, independent enterprises, organizations and institutions of the industrial and nonindustrial spheres regularly making use of the VTsKP* services on a long-term basis (a year or more) can become subscribers to the VTsKP. The enterprises, organizations and institutions using the various VTsKP services will be called VTsKP users.

The subscribers can use all of the services provided by the VTsKP; the users are supplied services during slack periods for the personnel and equipment of the VTsKP when performing planned work with respect to servicing the subscribers.

The interrelations between the subscribers and users, on the one hand, and the VTsKP, on the other hand, are established either on a contract basis or by the instructions of the superior agency to which the given computer center is subordinate.

The composition of the VTsKP subscribers is determined to a significant extent by the economic-geographic characteristics of the region, the level of its scientific-technical development, specialization of the national economy, and administrative significance. Among these factors are the following main factors: the level of industrial development of the region; administrative significance of the region (region with city-union republic republic capital, union republic without oblast division, kray, oblast,

*[Collective-use computer centers]

ASSR). The specialization of the national economy of the region is the basic factor in determining the branch uniformity of the subscribers.

The analysis made by the VNIIPOU of the regions of the country made it possible to estimate their potential demand for information computer services (IVR) and also the grouping and isolation of the standard regions. In such regions, the subscriber characteristics and their goals for standardization purposes are determined and studied.

The following composition of the subscribers can occur within the boundaries of the region:

1. Control agencies. This group of subscribers includes the following:

Directive agencies (Central Committee of the Communist Party of the union republic; kray, oblast, municipal, rayon committees of the CPSU; office administration of the Presidium of the Supreme Council of the Union (Autonomous) Republic; administrative apparatus of the Affairs Directorate of the Council of Ministers of the Union (Autonomous) Republic; the executive committees of the local Councils of Workers' Deputies);

Functional and branch government control agencies (ministries and departments of the union republics, ministries and directorates of the autonomous republics, directorates and divisions of the executive committees);

The public agencies and organizations (Komsomol agencies, the directing organizations of the trade unions, sports and volunteer societies and creative means).

2. The enterprises, the organizations and institutions of the material production sphere (with respect to branches of the national economy).

3. The enterprises, organizations and institutions of the nonproduction sphere (by branches of the national economy).

The composition of the second and third groups can include subscribers of both union, union republic, republic and local subordination.

The presented grouping of subscribers basically corresponds to the classification of branches of the national economy developed by the Central Statistics Directorate of the USSR.

All groups of the subscribers are distinguished both by constancy of composition for the various regions, degree of readiness for machine solution of the problems and the nature and volume of the solved problems. Thus, the composition of the subscribers in the first and third groups is constant to a significant degree. The second group of subscribers, especially in the industrial sphere, is distinguished by the greatest variety. For example, in one oblast there can be enterprises that are subordinate to

5-30 different union ministries and departments and 20-45 republics. A significant part of these enterprises (15-50%) are concentrated in the oblast centers. There are always enterprises and organizations subordinate to one ministry within the limits of one region. This is especially characteristic for regions specializing in any branch of the national economy. In particular, in the regions where the extractive production predominates (coal mines, mines, oil fields, forestry and lumbering, and so on), such enterprises number in the hundreds.

The given fact is an objective basis for the creation and effective utilization of the multi-user computer centers and the VTsKP. As has already been noted, the subscriber-representatives of the nonindustrial sphere and in particular the service sphere are uniform in the different regions.

Thus, for the representative subscribers of the first and third groups, favorable conditions have been created for standardization and circulation of the design operations.

The analysis of the VTsKP subscribers in the first phase has demonstrated the following distribution of the number with respect to branches of the national economy: control 31.2%, industry 25%, agriculture 5.0%, transportation 2.4%, communications 0.4%, construction 3.3%, trade and public feeding 11, material and technical supply and marketing 0.2, other forms of material production 0.4, residential and communal and domestic servicing of the population 0.2, public health 1.1, public education 1.5, culture 0.2, science 10, credit and state insurance 5%. Thus, in quantitative respects the control agencies, the industrial enterprises, scientific institutions, enterprises of trade and public feeding predominate.

The subscriber distribution with respect to priority of servicing has important significance in the organization of the collective-use process. When selecting the priority in servicing a subscriber it is necessary to consider such factors as the state importance of the functions performed by the given subscriber, the cost benefit of the problems solved at the VTsKP, the necessity for operative use of the results of solving the problems.

The analysis of the subscribers and their problems permits preliminary ranking of the subscribers by their servicing priority:

The enterprises and organizations of the constituent departments of the given VTsKP;

Territorial directive control agencies;

Territorial functional and branch control agencies;

Enterprises and organizations controlled on the basis of the automated control system of the region (the republic automated control system, oblast automated control system, city automated control system);

The enterprises and organizations, the automated solution of the problems of which offers significant cost benefit;

Other enterprises, organizations and institutions.

When determining the priority of the solution of the subscriber problems on the VTsKP, it is necessary to consider the priority of the subscriber himself and the requirements on the operativeness of solving the given problem. It is obvious that the priority of the problem must be reflected in the cost of its solution.

The subscribers to the servicing of the VTsKP impose a number of requirements, the analysis of which has made it possible to isolate the basic ones of them.

The requirement on accuracy of the results of the calculations performed on the VTsKP for the subscriber. It consists in the fact that the relative error in the output data must not exceed a given value. In the majority of cases this value is within the limits of 10^{-2} to 10^{-6}, and in individual cases to 10^{-7}. High accuracy of the solution must be provided in financial calculations of banking operations, for actual accounting for labor and wages, and lower accuracy, for planning and forecasting.

The requirement on regularity of the solution of the problems. The analysis of this subscriber requirement has demonstrated that with respect to frequency of solution, on the average the problems are distributed as follows: daily (10%), every 10 days (2%), monthly (75%), quarterly (4%), semiannually (1%), annually (8%).

The requirement on the urgency of solving the problems which reduces to giving the time interval between the times of arrival of the initial data on the problem and the output of the calculation results on it. Depending on the operativeness of the solution of the problem this interval is within the limits from several hours to 10 days.

The requirement on the duration of the storage of the results of solving the problems. For example, for the current accounting problems the storage time has taken from 3 months to a year, and for future planning problems, 10 years.

The requirement on protection of the subscriber information stored at the VTsKP. By the request of the subscriber, the access of other subscribers to this information can be open or limited. This requirement is especially stipulated, and in the presence of it, it must be observed uncompromisingly both on the part of the VTsKP and on the part of the subscriber.

The subscriber requirements include the wishes with respect to the type of information carrier (punch tape, display screen, document), maximum use of the standard design solutions, standard programs and packages of applied programs, previously installed equipment, and so on.

An important characteristic of one subscriber or another is the graph indicating the time distribution of his requirements for information computer services. The analysis of such graphs has demonstrated significant nonuniformity of the information load of the subscribers both for a month and for a year. Fig 1 shows the distribution of the volumes of input and output information processed by one of the representatives of the territorial control agencies -- the oblast planning commission. In the figure we see the characteristic increase in volumes of input information coinciding with the end of each quarter, the output information "peaks" have some leading displacement. Fig 2 shows the demand of the industrial enterprise for information computer services for a month. Here there are three explicitly expressed apexes: from the second to the tenth of the month, from the 14th to the 17th and from the 23d to the 25th of the month.

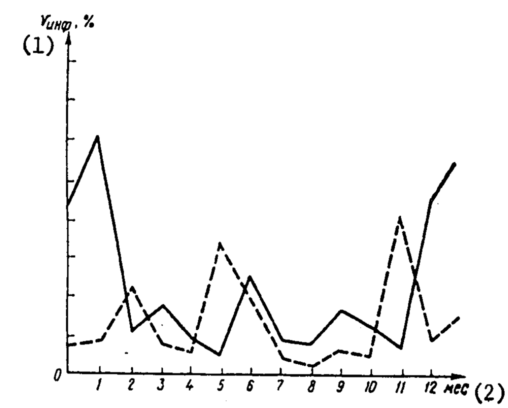

Figure 1. Distribution of the volumes of input and output (dotted line) information with respect to the oblast planning commission for a year

Key:
1. V_{inf}, %
2. Months

It is entirely natural that during the indicated periods the subscriber has special interest in the information computer services and its activity with respect to the use of the hardware. The given fact arises from objective causes: the existing planning and accounting system. It is necessary to note that such rhythmicity is not observed in subscribers turning to the VTsKP to solve scientific-research and engineering-technical problems.

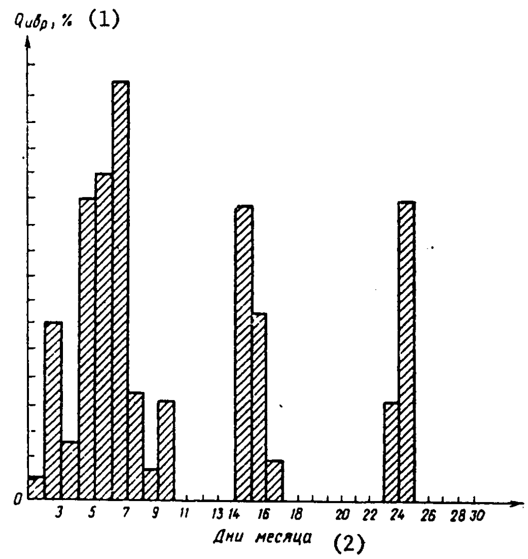

Figure 2. Distribution of the volume of information computer services with respect to industrial enterprise for a month

Key:
1. $Q_{\text{computer services}}$, %
2. Days of the month

The analysis of the information process modes of the subscribers within the boundaries of the city territory has demonstrated that the control agencies must process 40% of their information in the package mode, 50% in the "request-response" mode, 10% in the dialog mode. Analogous data with respect to industrial enterprises amount to 88, 8 and 4%; with respect to the nonindustrial enterprises, 90, 7 and 3%.

The operative information is 10-20% of the total volume of information output by the subscribers to the VTsKP computer centers. The goals of the VTsKP subscribers can be characterized with respect to a number of attributes. In our opinion, let us call the following basic:

The functional purpose of the problem;

Complexity of the resolving algorithms;

Frequency of solving the problems;

Efficiency of utilization of the results of solving the problem in the national economy.

In addition, the problem can be characterized by belonging to one group of subscribers or another.

Depending on the opposition of the subscribers in the control structure, their problems can be combined into several groups: the problems of the directive control agencies; the problems of the functional, branch and public control agencies; the problems of the associations, enterprises, organizations and institutions.

The first attribute identifies the problem of the corresponding control function or subsystem of the automated control system.

The next attribute characterizes the method used to solve the problem, and as a result, the volume of computer operations per unit of input information. Experience has shown that the specific volume of the calculations is different for the information-logical problems, the analysis problems, the solution optimization problems, and so on. The accumulation and generalization of such experience would permit the generation of a normative grid which, in turn, would promote acceleration of the design operations.

The frequency of solving the problem, being one of the basic subscriber requirements, permits determination of the uniformity of loading of the hardware of both the subscriber himself and the data transmission media, and the set of VTsKP hardware.

A special role is played by the estimation of the national economic effectiveness of the problem of the subscriber solved on the VTsKP. Unfortunately, as a result of the procedural difficulties this most important index of the problem has been insufficiently resolved, although it is obvious that the presence of even approximate estimates of the effectiveness of the problems (or the set of problems) would provide for evaluation of the effectiveness of the functioning of the VTsKP as a whole.

The analysis of the problems of the territorial (city and oblast) control agencies has permitted about 700 problems to be isolated which require computer solution.

The data on this analysis are presented below:

Name of Control Agency	No of problems
Directive agencies	30
Oblast planning	55
Oblast statistical directorate	82
Oblast Finance Division	42
Oblast marketing and supply	25
Oblast Directorate for Labor and Wage Problems	19
Directorates:	
Capital construction	23
Residential	92
Domestic services	18

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Local industry	14
Trade	100
Public health	58
Internal affairs	8
Motor transportation, communications	6
Agricultural	50
Main administration of culture, public education and social security divisions	85

Among these, 40% are accounting and monitoring problems 20% are the problems of analysis and operative control, 18% are current planning problems, 5% are future planning problems, and the rest are problems in organizing the normative base, statistical accounting and so on.

From the indicated quantity for first phase introduction it is possible to isolate about 30% of the problems beginning with the importance and degree of their preparation.

The preliminary estimation of the commonness of the problems of analogous subscribers belonging to the VTsKP of different cities has demonstrated the following:

With respect to the directive control agencies, of the entire set of problems, 43% are common for cities, 70% for a rayon;

With respect to industrial enterprises, about 50%. Basically, these are the problems of bookkeeping accounting, technical-economic planning. The remaining problems take into account the specific nature of production;

With respect to the trade enterprises, the bases and warehouses the common problems make up 34% -- these are the problems of accounting, statistical-bookkeeping reporting, calculations of overhead;

With respect to scientific research institutes, design offices, and training institutions, the percentage of commonness is insignificant and pertains to problems with respect to personnel accounting, bookkeeping accounting and statistical reporting. The basic proportion (~85%) is made up of scientific and engineering calculations which depend on the specific nature of the institutes and are still solved by individual algorithms.

From the presented data it follows that there are objective prerequisites and a necessity for the development of operations of standardizing the VTsKP subscriber problems. At the present time in the newly created VTsKP, the development of the subscriber problems is being carried out with respect to individual designs, as a result of which it is impossible to standardize the solution and, in addition, the planning and design time increases and material expenditures rise.

The degree of preparation of the subscribers for the use of the computer capacities of the VTsKP to solve their problems is different. In the territories serviced by the VTsKP, there are enterprises and organizations (basically the machine building enterprises) having already developed automatic control systems and work experience under the automation conditions. However, there are comparatively few (about 10%) such trained subscribers. For the rest, and majority of them, the work on introducing computer engineering is only starting, and it is being realized without a unified plan. In this sense, the VTsKP is recognized to render invaluable aid to the subscribers under the conditions of conversion to the third-generation computers.

It is obvious that the operations performed by the VTsKP must first of all be based on the already-existing developments of the automated control systems of the enterprises, the institutions, the territorial control agencies, and they must be oriented to the maximum possible standardization. Some of the ministries and departments are using the forces of their main institutes with respect to automated control system problems to carry out projects in standardizing the planning and design solutions for subordinate enterprises.

A necessary condition of the effective operation of the VTsKP is the creation of the state library of algorithms and programs. Nevertheless, this will not relieve the VTsKP of the organization of its own developed service to work with the subscribers, even in the presence of centralized development of the standard software and its accompaniment. Such a service must approach the subscribers and users individually, consider their specific requirements, teach them to work with the information under conditions of collective use of the hardware.

[389-10845]

10845
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PROBLEMS OF DETERMINING THE COST BENEFIT OF THE VTsKP

Moscow VYCHISLITEL'NYYE TSENTRY KOLLEKTIVNOGO POL'ZOVANIYA in Russian 1979 signed to press 4 Apr 79 pp pp 103-110

[Article by Yu. P. Gertsman]

[Excerpt]

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[389-10845]

10845
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CREATION OF THE COLLECTIVE-USE MAIN COMPUTER CENTER OF NATIONAL ECONOMIC PLANNING AND CONTROL OF THE Latvian SSR

Moscow VYCHISLITEL'NYYE TSENTRY KOLLEKTIVNOGO POL'ZOVANIYA in Russian 1979 signed to press 4 Apr 79 pp 132-147

[Article by M. L. Raman, R. V. Soms]

[Excerpts] The introduction of the first phase of the main collective-use computer center into operation in Riga is planned for the second half of 1979. At the present time the technical assignment for creation of the main computer center has been approved in which the basic requirements in the concept of its development in 1980 and subsequent years are reflected.

The basis for the hardware base of the main collective-use computer center in the first phase will be the Siemens 4004/150 computer which has been put into operation with ready-access memory of 512 K, an output capacity of 490,000 operations/sec with 8 magnetic discs of 55 Mbytes each, the M-4030-1 computer with ready-access memory of 256 K with 4 magnetic discs of 29 Mbytes each, the basic version of the SM-3 minicomputer and the Minsk-32 computer.

For the first phase of the subscriber network there are 23 video terminals, of which 8 have printers and 2 have dialog stations. For data input to the computer and preparation of the corresponding technical carriers (punch tapes, punch cards and magnetic tapes), in addition to the corresponding card and tape punches, there is also a system for recording the data on magnetic tape -- the 1302 built by the Inforeks Company. The magnetic tapes of the Minsk-32 and the unified system of computers can be used for data input to the automated data bank of the Siemens computer. The results of the calculations in the form of data files can be output in accordance with the requirements of the formating of the magnetic tapes on the unified system of computers or the Minsk-32 and also the punch tapes for filling out the standardized forms of planning documents on the Optima orgavtomat.

Putting the main collective-use computer center into operation at the present time requires a great deal of work with respect to creating the information base for the solution of the user problems in the package and the dialog modes. Perhaps this is one of the most complex and most labor-consuming measures, for, in our opinion, the VTsKP must service the subscribers not only with the computer machine time as has been practiced up to now, but insure servicing of the users of the required information for solving various types of their problems. The methods of solving this problem in the final analysis will determine the expediency of creating the VTsKP and the effectiveness of its operation.

The "population" ABD [automated data bank] provides for the accumulation, actualization and storage of demographic and social-economic information about the population. The necessity for creating the "population" system follows from the growing requirements of the planning and control agencies for obtaining reliable and multi-aspect information about the population. The existing information about the population is primarily based on the population census materials that are taken once every 10 years by the program which does not encompass a number of basic population characteristics. The various forms of accounting used in the organizations, the enterprises, institutions and businesses of the country are scattered, they serve to solve local problems and they do not provide a systems approach to the information about the population.

The traditional methods of accounting have become unsuitable when it is necessary to plan the high-quality utilization of manpower in the territorial sections. Now, under the conditions of technical progress and insufficiency of labor resources, the development of the complex plans for the development of the individual large rayon projects and individual accounting for people in various specialties are acquiring primary significance.

When planning the most important solutions with respect to planning the development of small and medium cities of the country data are required not only on the quantitative but also the qualitative composition of the population living in a defined location. It is necessary to have at our disposal information about each resident permitting us to obtain data not only in the territorial sections, but also with respect to defined economic regions.

The consideration of such data about each republic resident (2.5 million people) is provided by the "population" system. Using documented data on each civilian, the system can generate results which completely satisfy the statistical requirements, and at the same time can publish data both with respect to each man individually and with respect to their group values.

Thus, the information obtained in the data bank of the "population" system insures the initial data for solution in the automated mode not only of the labor-consuming planning, statistical and analytical problems of our population, but also permits the solution of theoretically new problems of planning of economic and social development. It is possible, for example, to indicate the following problems, the solution of which is provided for by the "population" system:

The development of the master plans for the development of the cities and economic regions;

Planning of passenger flows and the development of the transport network under the conditions of fast growth of residential construction;

Planning of the placement of the commercial and communal enterprises, children's institutions and schools;

Planning of industrial construction on the basis of the analysis and forecasting of manpower resources (jointly with the capital construction system);

Planning of the construction and distribution of new living space (jointly with the communal management system);

Performance of settlements for communal services;

The compilation and printing up of various lists (voters, students, and so on), and forms of accounting;

The planning of the processes of natural, social and mechanical movements of the population.

The "population" system is created as an experimental automated system for gathering and processing demographic and social-economic information about the population. It is constructed on the basis of the integration of a number of automated systems for the creation of the unified information file required for the planning and control of manpower within the framework of the automated planning calculation system of the Gosplan of the Latvian SSR (ASPR of the Gosplan of the Latvian SSR), the planning of economic and social development of the republic, improvement of the standard of living of the population and improvement of the solution of problems with respect to the republic population within the ASGS system of the Central Statistics Administration of the Latvian SSR.

The basic file of entries on the residents will make it possible for us to tie together the automated control systems developed and introduced in the republic which are working with information about the population on the basis of individual data on each man.

The data source for the "population" automated data base is the rayon certificate divisions of the ispolkoms and the republic address office of the Ministry of Internal Affairs of the Latvian SSR. The primary data input to the automated data base is realized simultaneously with the generation of new certificates. In each phase, about 25% of the population living in Riga have been introduced into the data bank. The "population" automated data base has already been used as the information retrieval system for the republic address office working in the dialog mode. The requests to the automated data base and the output of results are realized by dialog programs, for working with which special training is not required. The time required to wait for an answer to a request does not exceed several seconds.

Thus, the "population" system can be considered as a new type of government information system providing for effective solution of the qualitatively new planning and control problems. The created system provides for the use of the existing principles of the protection of information about the population from illegal use and divulgence.

Such measures include the following:

Determination of the list of data generated by each organization in accordance with its competence;

Determination of the class of people in each organization having access to the information and the existing nomenclature of the indexes.

In addition, the system provides for a number of organizational and technical measures with respect to the protection of the information:

Insurance of protection of the peripheral devices from the access of outside people to them;

The release to each user of a key for access to the automated data base and its component parts;

Program methods of protection including the protection of the files and connection of the data processing procedures with respect to the key;

Insurance of protection of the hardware and the information carriers from arbitrary connection to them or failure;

The creation of the service for updating and maintaining the automated data base and protecting the data at the GVTs KP [collective-use main computer];

Significant work is being done with respect to creating the automated data base for the technical-economic indexes for solving the problems of social and economic development of the republic (ABD ASPR). The created problem-oriented file of aggregate data is designed to solve the problems of inter-branch and branch control agencies. The composition of the restored indexes will be determined beginning with the information requirement of the problems of the first stage functional subsystems of the ASPR.

The description of the economic indexes was such as to insure organization of the indexes with respect to functional subsystems; the possibility of grouping and selecting the indexes with respect to the set of isolated attributes or with respect to each of them; the possibility of parallel loading of the information of the various systems into the data bank with simultaneous observation of the requirements of one-time information input.

The set of economic indexes having common attributes by which the selection or grouping of information is realized when solving the problems of the users are formed into one data library.

The gathering of the information for the automated data base is on effective forms of documents which are adapted for computer processing or in the form of machine carriers obtained from the information source in a previously stipulated format. The control of the input documentation and its reformatting are accomplished with the use of the standard monitoring and reformatting system.

At the present time in connection with the fact that the formation of the individual data files with respect to capital construction, communal management and population still has not been completed, the formation of the automated data base with aggregate data is being carried out in parallel with the individual ones with respect to the unified technical flow chart. However, hereafter the possibility will be provided for to obtain accurate data from the automated data base as it is updated.

The solution of the problems of the users on the basis of the information stored in the automated data base of the ASPR is possible in package and in dialog modes. The results of the calculations can be isolated either on the screens of the display, or in the form of the printed document of the ATsPU, or on the machine carriers, magnetic tapes, magnetic discs, punch tapes.

As the class of solved problems expands for the needs of planning and control, accumulation of data in the automated data bank, provision is made for staged growth of the power of the GVTs KP computer center and the corresponding improvement of the software system. The design solutions have been developed for stepped development of the hardware set for the GVTs KP computer center and the subscriber stations until 1985 providing for the following:

Growth of the power of the hardware to provide for the creation of the automated data banks of all of the systems provided for in full volume and their operation in the dialog and package modes;

The operating of the computer permitting the creation of a multimachine data processing system having increased readiness, reliability and viability, capable of granting a wide assortment of services to the system users;

Support of the possibility of redistribution of the computer operations in the system and also the possibility of working in the computer center network;

The possibility of creating a broad network of subscriber stations among the users and the branched remote data processing network.

For redundancy of the Siemens-4004 computer, the insurance that an automated data base will be created in the noted volumes, for broader use of standard software, provision is made for putting together the Siemens-4004 and the M-4030-1 computers on the external memory level. This composition will be the preparatory step for the creation of the multicomputer system.

For purposes of performing increasing volumes of computation operations, provision is made for the connection of the YeS-1055 or the YeS-1060 computers in the system. For efficient use of the resources of the computer complex, the distribution of assignments among the computers, the output of the results of performing all of the packages of problems, it is proposed that the general control processor or user complex distributor be created on the basis of the YeS-1022 computer.

A working design section has been developed at the GVTs KP computer center "the subscriber data transmission network of the GVTs KP computer center operating in the dialog mode." At the present time 15 subscriber stations are operating among the users of the GVTs KP computer center. The subscriber network must provide the following:

Information support of the directive agencies in the reference mode;

Solution of the problems of the users testing and processing of the procedural materials and software for solving the user problems;

Checking the reliability and completeness of entries in the automated data bank;

The introduction of changes and additions to the operating data bank if special permission is given for this.

In connection with the fact that there are insufficient subscriber stations, provision has been made for servicing of several ministries and departments by one terminal device (display). The further development of the network of subscriber stations is planned by broad use of the SM-3 minicomputer, SM-4, Iskra-126, the YeS-1010 computer, and so on.

The basis for the software in the first phase of the GVTs KP computer center is the developed systems software of the 4004/150 computer including the BS-1000 operating system, the data base control systems (SUBD) and the packages of applied programs.

As the data base control system, the "Sezam" system was selected which is universal for storage, control, retrieval and output of the formatted data with variable structure. The given SUBD is working on the automated creation and management of the data bank. The physical organization of the data and the recording of them are optimized by the system itself. Provision has also been made for a developed system for protection against unsanctioned access tot he data banks realized by keeping a catalog of keys (user codes). The physical protection of the data is realized by the principle of redundancy of the information on the magnetic protection tapes.

The 4004/150 computer switches on the other highly developed data base control systems oriented for management of files of other structures, their data protection principles. There are systems oriented predominantly to the dialog mode of the utilization of the information accumulated on the magnetic carrier. They permit operation with a significant number of subscribers in real time.

In addition to the data base control systems, the program library is kept which, in particular, includes the methods bank -- the system of standard programs for the mathematical methods used in solving production, economic and scientific-technical problems (for example, approximation calculus, statistics, differential and integral calculus). The bank of methods works under the control of the user programs.

There is also a package of applied programs permitting operative solution of various classes of problems of the PERT type, optimization of the production process, simulation of digital and analog processes.

In accordance with the concept of the development of the hardware base for the GVTs KP computer center and solution of the problems of composition of the computers, the resolution of the problem of compatibility of the software for the 4004/150 computer and Soviet computers has been given top priority with respect to software. In our opinion, the most prospective is coupling the 4004/150 computer to the M-4030 computer considering the actually functioning operating data base control systems. The primary goal of this software is the organization of the interaction between the computers entering into the computer complex, provision for the transmission of the stored data to the automated data base from one computer to another and also the solution of the problems of the package or dialog modes on one of the computers operating in the complex. Therefore the operations with respect to creating the coupling modules are exceptionally important for the flexible composition of individual programs and program systems.

Work is being done simultaneously on the assimilation of the software for the unified system of computers, in particular:

The operating system OS 4.1 and 6.0 providing for multiprogram operation and processing of messages from remote devices in unpredictable time intervals;

The universal data bank control system, "Oka," adopted at the ASPR;

The control system for the territorially distributed "Kama" data bases providing form ultisubscriber operation.

The assimilation and introduction of the software for the operating system of the unified system of computers will be realized in close cooperation with the main organizations for the development of the corresponding software.

Calculations have been performed to find the cost benefit of the collective-use main computer centers. The cost benefit was determined by comparing the expenditures on creating the collective-use main computer centers with the economy of expenditures occurring in connection with giving up the construction of the departmental computer centers and the saving obtained as a result of introducing the first phase functional complexes of the RASU of Latvia for the subscribers to the collective-use main computer centers. With the corresponding volumes of capital investments in phase I of the collective-use main computer center, the calculated annual cost benefit from introducing the collective-use main computer center considering the normative efficiency coefficient of 0.3 will be about 1.8 to 2.0 million rubles.

[389-10845]

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MULTICOMPUTER COMPLEXES BASED ON OLDER MODELS OF THE YeS EVM [UNIFIED COMPUTER SYSTEM]

Moscow VYCHISLITEL'NYYE TSENTRY KOLLEKTIVNOGO POL'ZOVANIYA in Russian 1979 signed to press 4 Apr 79 pp 148-159

[Article by B. I. Yermolayev, M. B. Tamarkin]

[Excerpts] One of the most effective methods of simultaneously improving the efficiency, the viability and the output capacity of the computer systems is combination of the computers into complexes.

The preliminary calculations indicate that when coupling two computers in a complex, the time worked per failure increases (in the ready-reserve mode) by three-five times, the viability of the system increases, for failure of one processor, the total output capacity of the system decreases, but the possibility of solving the most important problems is maintained. In addition, as a result of the formation of complexes, in practice the output capacity of the system can be doubled (when processing independent problems) by comparison with the operation of one computer.

The relative carrying capacity of the computer complex when solving independent problems can be estimated as follows.

The computer complex made up of two computers can be in three states: two computers failed, one computer in order, two computers in order.

In accordance with the above-enumerated states, the carrying capacity of the computer complex when solving independent problems will be estimated by values of 0.1 and 2. This provisionally indicates the number of independent problems which can be processed in the given state.

The failure intensity of the computers will be denoted by λ, the reproduction intensity, by μ, then the transfer diagram of the system in which the states and intensities of the system transfers are presented has the form presented in Fig 1.

When describing the mathematical model of the functioning of the computer complex (for preliminary estimation of the relative carrying capacity) we shall use the semi-Markov process with gains [1] which is described by the system of linear equations

$$0 = V_1 - g\frac{1}{2\mu}, \quad V_0 = 0;$$
$$V_1 = V_2\frac{\mu}{\mu+\lambda} - g\frac{1}{\lambda+\mu} + \frac{1}{\lambda+\mu};$$
$$V_2 = V_1 - g\frac{1}{2\lambda} + 2\frac{1}{2\lambda},$$

where V_i are the relative weights [1], and g is the relative carrying capacity of the computer complex.

In solving this system, we find the expression for the carrying capacity in the form

$$g = \frac{2\mu}{\mu+\lambda}.$$

Fig 2 shows the carrying capacity as a function of the failure and repair intensities. The indicated relations show that if the reliability indexes are insured which are indicated in the technical specifications for the computer, then on combining them into the computer complex, in practice doubling of the carrying capacity of the system is achieved.

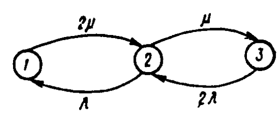

Figure 1. System transfer diagram

The architecture of the hardware and the software of the unified system of computers permits the design of multicomputer complexes based on combining the computers on the processor level with the help of the direct control means, on the input-output channel level using the channel-channel adapter, and on the level of the devices for controlling the external memory by means of the two-channel switches.

For sufficiently broad application in various high-output computer centers, the computer complexes based on the YeS-1050 and the YeS-1060 computers can be recommended (Figures 3 and 4).

The investigated computer complexes have approximately equal capabilities with respect to the number of compositional levels, carrying capacity of each level and the capability of the input-output system. However, the differences in structure and in composition of the devices used in the complexes, the differences in the software determine various capabilities and the sphere of application of the indicated complexes.

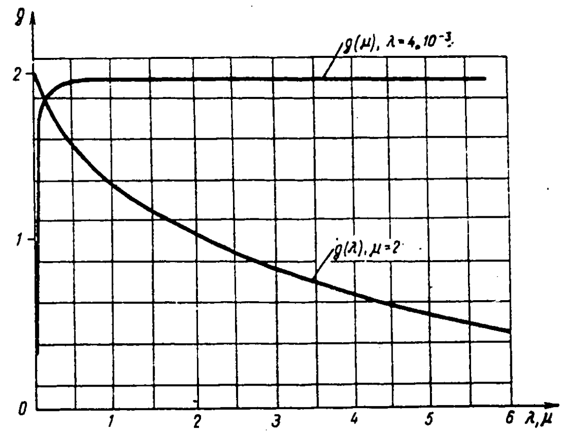

Figure 2. Carrying capacity of the computer complex as a function of the reliability parameters of the computer

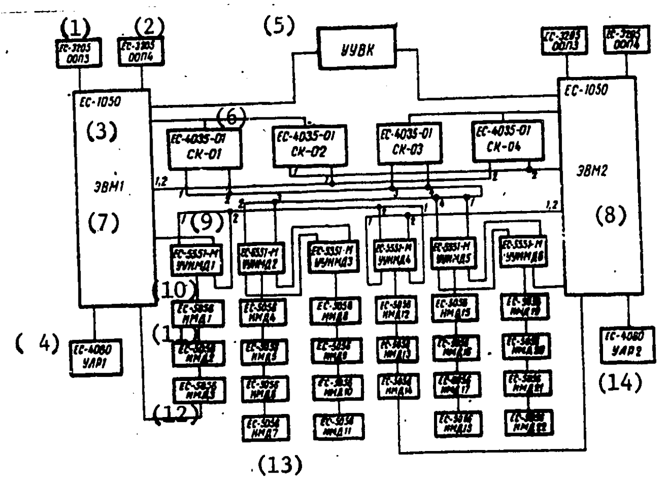

Figure 3. Structural diagram of the computer complex based on the YeS-1050

Key:

1 -- YeS-3205 OOP3; 2 -- YeS-3205 OOP4; 3 -- YeS-1050; 4 -- YeS-4080 ULR1; 5 -- UUVK computer complex control; 6 -- YeS-4035-01 SK-01; 7 -- EVM1 computer; 8 -- EVM2 computer; 9 -- YeS-5551-M UUNMD1 magnetic disc control; 10 -- YeS-5056 NMD1 magnetic disc; 11 -- YeS-5056 NMD2 magnetic disc; 12 -- YeS-5056 NMD3; 13 -- YeS-5056 NMD7; 14 -- YeS-4080 ULR2.

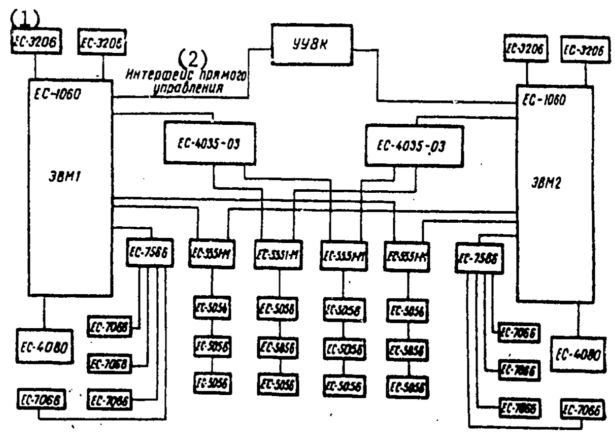

Figure 4. Structural diagram of the computer complex based on the YeS-1060

Key:
1 -- YeS-3206; 2 -- Direct control interface

The computer complex (see Fig 3) has processors in its composition which realize all-purpose setup of instructions and function with an output capacity of 500,000 operations/sec, the possibility of increasing the ready-access memory to 1024 Kbytes, and input-output channels with a carrying capacity to 1.3 Mbytes/sec.

The computer complex based on the YeS-1050 permits the fail-safe operating time to be increased as a result of the appearance of mutually replaceable devices with respect to the YeS-1050 by no less than 5 times. By mutually replaceable devices we mean the devices, the failure of one of which will not lead to failure of the computer complex as a whole.

The investigated computer complex is designed for the solution of a large class of scientific-technical, economic and specialized problems in the package processing, time sharing and real time modes.

The computer complex including two of the YeS-1060 computers has expanded capabilities of multicomputer processing which arise from the presence not only of a virtual memory, and expanded set of instructions and an expanded interrupt system, but also the increase in ready-access memory to 8192 Kbytes, the presence of high-speed all-purpose input-output channels with a carrying capacity to 3 Mbytes/sec and the possibility of connecting the storages based on interchangeable magnetic discs with a capacity of 100 Mbytes.

As has already been noted, the computer complexes based on the YeS EVM [unified system of computers] are the computers combined using the direct control means, the channel-channel adapters and two-channel switches. In this case the component hardware is supplemented by software, the basic principles of the construction of which are described in reference [2].

The means of direct control are the means of fast communication of small batches of data between the central processors. Usually they are used to exchange control information. One processor can be coupled to the other processor by means of the special instructions PRYAMAYA ZAPIS' [DIRECT WRITE] and PRYAMOYE CHTENIYE [DIRECT READ] and also the external interrupt mechanism.

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10845
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DATA TRANSMISSION IN COLLECTIVE-USE COMPUTER CENTERS

Moscow VYCHISLITEL'NYYE TSENTRY KOLLEKTIVNOGO POL'ZOVANIYA in Russian 1979 signed to press 4 Apr 79 pp 159-179

[Article by Yu. N. Cherkasov, L. Yu. Bedova, L. M. Gvozdeva, L. I. Ivanushkina]

[Excerpts] Two methods of transmitting packets are known in the access proceedings: "Datagram" and "Virtual channel."

When using the "Datagram" method, the user-sender (process) equips the data packet with the full address of the destination required for transmission of the packet through the network, and the network does everything possible to transmit it. The network sends each datagram independently so that it will reach the destination point with minimum delay. When using this method a complex software is required, for under the conditions where each datagram is processed independently, the network does not provide protection against loss of data, reordering of the data and prevention of overloading of the lines coupling the terminals or the VTsKP to the network.

When using the "Virtual channel" method the transmission of any message is preceded by two-way request-confirmation exchange between the source and the receiver. Here the information packets carry a minimum of service information, and there is an organized flow of data between the data source and the network with the packet commutation.

The responsibility for errors in transmitting the packets and loss of packets lies with the interacting elements, that is, also the packet commutation centers. The exchange rules and procedures when using the "Virtual channel" method are investigated in detail in the following section.

It is possible to state that beginning with the optimal combination of requirements of the users for data exchange with the VTsKP in all of the interaction modes -- from dialog to file exchange -- with the possibilities of effective data transmission over the communications system, the structure of the VTsKP data exchange system appears most efficient the basis for which is the switching of the packets using the data concentrators on the lower level and realization of virtual access to the packet commutation network both from the packet type terminals and nonpacket type.

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ORGANIZATION OF REMOTE SUBSCRIBER ACCESS TO THE DATA PROCESSING SYSTEMS AT THE VTsKP

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[Article by S. I. Baranov, V. V. Nikonov, A. L. Shchers]

[Excerpts] Hardware for the STO VTsKP [Remote Processing System of the Collective-Use Computer Center]

The entire set of hardware for the STO [remote processing system] created on the basis of the computer center of the All-Union Scientific Research Institute of Organizational and Control Problems under the GKNT (VNIIPOU) consists of the presently series-manufactured devices of the YeS EVM [unified system of computers].

At the central data processing computer, the YeS-1030 is used; for data storage, the direct access memory is used based on the magnetic disc storage (NMD) of the YeS-5050. The hardware of the local remote processing network includes the following: the MPD-3 (YeS-8403) data transmission multiplexor made up of synchronous and asynchronous adapters; YeS-8001 modems; the telephone communication channels; the AP-70 (YeS-8570) subscriber stations.

The subscriber stations are connected to the central computer using the unswitchable telephone communications channels. The unswitchable communication channel realizes constant connection of the subscriber station to the computer or connection for a previously established time interval. In this case the connection of the subscriber station makes the communication channel ready for use. The carrying capacity of the channel of 100 baud provides for data transmission in the KOI-7 code with the maximum rate of 10 symbols/sec.

The data exchange with respect to the communication channels is regulated by the linear procedure which enters into the basic telecommunications access method (BTAM) in the form of a program element. The procedure used at the present time controls the transmission of messages over the segregated channel of single-point configuration in the competition mode.

It must be noted that under these conditions the start-stop nature of operation of the AP-70 in the long-block mode requires the presence of a physical connection for all of the interaction time of the subscriber station with the central computer. The given circumstance and also the fact that the actual speed of the data transmission is equal to the operating speed of the subscriber station operator (the symbol-by-symbol transmission with arbitrary time intervals between adjacent symbols in the module) lower the effectiveness of the use of the equipment and the communication channels. Hereafter, considering the capabilities built into the YeS-8570 (its addressability in the presence of the short-block mode) it is proposed that the present linear procedure be modified and that the data be transmitted over the communication channels of multipoint configuration in the centralized control mode.

The YeS-8570 subscriber station and data transmission multiplexor YeS-8403 are equipped with the mechanism of block-by-block matrix code for monitoring the information transmitted over the communication channels. The AP-70 provides for automatic response to a block of communications received from the computer. The symbol "DA" [YES] sent by the subscriber station after receiving the block is considered as a positive answer (the subscriber station has received a block of information without errors), and the symbol "NYeT" [NO] is taken as the negative answer (the subscriber station has received the block with an error). As has already been noted, for information exchange the KOI-7 transmission code is used. The presence of the interrupt means makes it possible for the subscriber station user to interrupt the output of unnecessary information.

For convenience of the work of the users the YeS-8570 subscriber station is equipped with means of automated forming of the control symbol for the end of the block (KB) when pressing on the carriage return key. This reduces the number of manipulations with the keyboard for setting up the control symbols.

Software

The software of the remote processing system at the VNIIPOU computer center was developed on the basis of the dialog remote input of assignments (DUVZ) which uses the BTAM access method. The system was implemented in the operating system OS 4.1. In order to insure fitness of the system it turned out to be necessary to modify a number of the program modules which are components of the version of the OS 4.1 operating system existing at that time in order to emulate the AP-70 equipment for the program elements of the remote processing subsystem. The first startup of the subsystem was on 27 December 1977.

For the functioning of the subsystem it is necessary to have 256 K of ready-access memory in the MFT version of the operating system or 512 K in the MVT version. The following requirements are imposed on the direct-access memory:

No less than the volume of one YeS-5050 disc for the system libraries. Exact requirements depend on the number of system users and simultaneously connected subscriber stations, the number of simultaneously processed transactions;

No more than 100 tracks on the YeS-5050 magnetic disc storage for the system modules to be placed;

For the operating memory (the active region) no less than three cylinders are needed on the YeS-5050; of them 30 tracks will be used for systems information;

For storing the data base it is necessary to have no less than one YeS-5050 disc.

The remote data processing subsystem provides for the following: the processing of messages (transactions) input from the subscriber station in the dialog and packet modes, commutation of messages, restriction of the information in the data bases with organization of multiaccess, planning of the execution and the completion of applied programs, access to the data bases by users working from the remote AP-70. Under the control of the remote processing subsystem several applied programs can be executed simultaneously, the number of which is determined by the number of zones of the ready-access memory occupied by the solution of the problem. The diagram of the transactions is illustrated in Fig 1 in which it is shown that the data base is constantly in the secondary memory, and the data are transmitted to the primary memory for processing after access to the corresponding couplings. The applied programs are also in the external memory. For their execution the service program must be loaded into one of the free zones of the ready-access memory.

The connection of the terminal operator to the system takes place by setting up the user identifiers in the operand field of the DUVZ command LOGON, which establish the communications between the operator and the system. The identifiers are checked by the system table which contains the names of all the terminal operators.

In conclusion it is necessary to note that on the basis of the low speed of the AP-70 the remote processing system using the latter can be recommended only for operation of a remote user in the "interrogation-response" mode with transmission of several batches of operative information. For input-output of large documents it is necessary to use the packet processing subscriber station with high-speed printers.

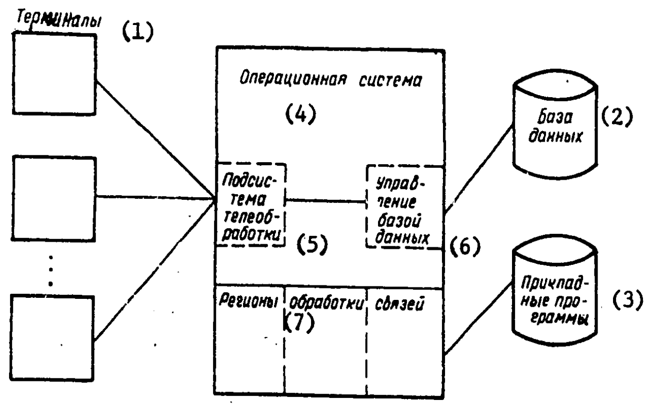

Figure 1. Diagram of the operation of the data base control system of the automated control system implemented at a remote VTsKP [collective-use computer center]

Key:
1. Terminals
2. Data base
3. Applied programs
4. Operating system
5. Remote processing subsystem
6. Data base control
7. Coupling processing regions

[389-10845]

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LIBRARY OF ALGORITHMS AND PROGRAMS FOR THE VTsKP [COLLECTIVE-USE COMPUTER CENTERS]

Moscow VYCHISLITEL'NYYE TSENTRY KOLLEKTIVNOGO POL'ZOVANIYA in Russian 1979 signed to press 4 Apr 79 pp 205-227

[Article by A. V. Vladytskiy]

[Excerpts] In the table the program packages are presented which are made up of the programs available at the present time in the GosFAP [State Library of Algorithms and Programs] recommended for inclusion among the program materials of the libraries of algorithms and programs created at the collective-use computer centers.

Groups and designation of the applied programs and packages of applied programs	Purpose of the applied programs and packages of applied programs	Type of operating system	Minimum required volume of ready-access memory, Kbytes	Language in which the applied programs and packets of applied programs are written	Remarks
1	2	3	4	5	6
	1. Applied Programs for Solving the Problems of Automated Control Systems				
1.1. Applied programs for organizing a data bank					
1.1.1. Universal-structure data bank ("Bank" system)	The "Bank" system is a set of means designed for the correction and processing of the centralized information library in which the composition of the data and the interrelations are defined	DOS YeS*	-	Assembler	
1.1.2. Data bank of the automated production control system	Designed for the creation, servicing and correction of the data base	OS YeS**	128	Assembler, Cobol, PL/1	The SIOD-1 and SIOD-2 versions exist

*Disc operating system of the unified system
**Operating system of the unified system

1	2	3	4	5	6
1.1.3. Integrated processing system of the data bases of hierarchical structure (SINBAD)	SINBAD provides for the creation and the management of the data bases designed for broad application, and it also serves as a means of adaptation of the software to the specific data processing conditions	OS YeS	198	YaOD, YaAM	
1.1.4. Sectional-oriented programming system (NSI-1-DOS)	Designed for creating data files of different content, updating them and retrieving the required information	DOS YeS	64	YaOD, YaUZ	
1.1.5. Sectional-oriented programming system NSI-DOS (SOSP-NSI-DOS)	The SOSP-DOS is an all-purpose program generator for the organization of the data bank and the programs for processing the information stored in it	DOS YeS	32		
1.1.6. "Bank service" software system	Designed for automation of the processes of determining the data and programming base for the specific information systems	DOS YeS	128	Assembler	
1.1.7. The "Bank-OS" software system	Is a set of universal programming means for organizing the data banks of universal structure	OS YeS	20 per problem	Assembler	
1.1.8. System for monitoring the data banks of hierarchical structure (SINBAD-2)	Is a universal system for controlling the data bases created for the expansion of the possibilities of the user during multiaspect processing of the centrally stored data	OS YeS	256	Cobol, PL/1, Assembler	

1	2	3	4	5	6
1.1.9. "Information base of the automated control system" software system	This system is a set of declarative and program means which provides for automated management of an intracomputer information base for an automated control system which is universal with respect to structure and composition	DOS YeS	64		
1.1.10. "Organization and maintenance of dictionaries" PPP*	Designed for the organization and handling of information which makes up a set of dictionary positions including the code and information parts	DOS YeS	64		
1.1.11. "Organization and file archive management" PPP	Designed for keeping the archive of files used when solving automated control system problems	DOS YeS	64		
1.1.12. "Data" PPP	Designed for automation of the input and storage of data in the information base and also for automation of obtaining information from the base	DOS YeS	to 20 million bytes	PL/1	
1.1.13. "Servis-2" [Service-2] PPP	Designed for the creation and management of the intramachine information base of the automated production control system with linear file structure, automation of the computer process and automation of the programming of some of the general procedures	DOS YeS	64		

*Package of applied programs

1	2	3	4	5	6
1.1.14 "Information system base servicing system" PPP	Developed in the procedure for further development of the SIOD-1 and SIOD-2 software systems, and it can be used only together with the systems	DOS YeS	64		
1.2. Applied programs for solving the functional problems of the automated control systems					
1.2.1. PPP for automated material and technical supply and wholesale trade enterprise control systems (PPP-MTS)-(TsSUP)	PPP-MTS is a set of programs and instruction materials providing for automatic writing of programs to solve the accounting and control problems at the enterprises of the MTS and wholesale trade	DOS YeS		Assembler or PL/1	
1.2.2. "Reserve control" PPP (PPP-UZ)	Designed for automated solution of the problems of controlling the reserves of material resources at industrial enterprises	DOS YeS	32	Assembler and PL/1	
1.2.3. "Planning for demands" PPP (PPP-PP)	Used to generate the working programs used in the automated enterprise control systems with digital nature of production	DOS YeS	32		
1.2.4. "Transport problem" PPP (PPP-TZ)	Offers the possibility of the user to solve the problems of linear programming of the transport type by means of an easily available procedure	DOS YeS	64	Assembler Fortran	

1	2	3	4	5	6
1.2.5. PPP "SMO-RESURSY" [Résources-software system]	Designed to solve the problems of the distribution of limited resources (unaccumulated type) by the PERT method	DOS YeS	-	Assembler	
1.2.6. PPP for the transport organization automated control system (PPP "Transport")	Designed for the development of the automated port control system	DOS YeS	-	Assembler	
1.2.7. "Retail trade" PPP (PPP-RT)	Used for automation of the development of the software for automated retail trade enterprise control systems and aimed at the level of control of the trade of a large city	DOS YeS	-	Assembler, PL/1	
1.2.8. "Planning and production control" PPP (PPP-OUOP)	Designed for operative control of an industrial enterprise considering the production in the corresponding amounts and at the established times	DOS YeS	64		
1.2.9. "Capacity planning" PPP (PPP-PM)	Used for calculating the production capacities required to execute the finished product production plan	DOS YeS	47	PL/1	
1.2.10. "Shop control" PPP (PPP-UTs)	Designed for compiling short range plans for a week, 10 days, a month for the sections of the machine building plants	DOS YeS	63	PL/1, Assembler	

1	2	3	4	5	6
1.2.11. PPP for controlling the capacities and operative control (PPP-UMOU)	Applied for the planning of the requirement of capacities and determination of the sequence for performing the operations at the enterprises	DOS YeS	64	Assembler	
1.2.12. Fixed capital control PPP	-	DOS YeS	-	-	
1.2.13. "Technical-economic planning" PPP (TEP-DOS)	Designed for planning, accounting, monitoring, management of the fixed production means and objective analysis of their development	DOS YeS	-	-	
1.2.14. "Marketing control" PPP (PPP-sbyt)	Designed for the planning and operative accounting for the shipping of the production by the enterprises producing a product both for the internal market and for export	DOS YeS	-	-	
1.2.15. "Material and technical supply" PPP (PPP-MTS)	Used for the solution of the problems of planning, calculation of requests, realization of the material stocks, the arrival and outgo of materials, the placement of materials, normalization of the reserves and statistical accounting with respect to materials	DOS YeS	64	-	
1.2.16. "Bookkeeping accounting" PPP (PPP-BU)	Designed to solve the problem of the automation of the calculation information processing with suppliers and purchasers	DOS YeS	64		

1	2	3	4	5	6
1.2.17. "Mechanized warehouse" PPP	Designed for the control of the acceptance procedures, the placement, the output and consideration of the loads in the central warehouse area or other shelf warehouses	DOS YeS	32	-	
1.2.18. "Accounting of financial-calculation operations" PPP	Used for the automation of the functions of bookkeeping accounting connected with cash register and bank operations	DOS YeS	64	PL/1	
1.2.19. "Accounting for fixed means" PPP	Designed for the automation of the functions of bookkeeping accounting connected with considering the fixed means with respect to places of storage and use	DOS YeS	64	PL/1	
1.2.20. "Material values" PPP	Designed for automation of the bookkeeping accounting functions connected with the procurement of material values, movement of them at the warehouses, and so on.	DOS YeS	64	PL/1	
1.2.21. "Accounting" PPP	Used in the branch automated control systems for input, monitoring, recording and extracting information from the data base by request	DOS YeS	128		
1.2.22. "Labor and wage accounting" PPP	Designed for automation of the bookkeeping accounting functions	DOS YeS	64	PL/1	
1.2.23. "Capacity planning" PPP	Designed for determination of the loading of the work areas by the commercial production enterprise output plan	DOS YeS	128		

1	2	3	4	5	6
1.2.24. "Demand planning" PPP	Used to calculate the plans and charts for starting parts and assembly units through the plant beginning with the commercial production output chart	DOS YeS	128		
1.2.25. "Wholesale trade" PPP	Used to solve the problems of accounting, planning material reserves at the sites of the nonindustrial sphere and controlling the material reserves	DOS YeS	64		
1.2.26. "Personnel" PPP	Designed for automation of certain functions of the control of the personnel of the industrial enterprises and organizations	DOS YeS	64	YaMD	
1.2.27. "Optimizing the technological processing of economic information at the branch automated control system" PPP	Designed for controlling the solution process and also for monitoring the sequence of the solution of problems of the branch automated control system and other automated control systems	DOS YeS	64	Assembler, Fortran, RPG, Cobol, PL/1	
1.2.28. "Capacity planning and operative control" PPP	Designed for operative-calendar planning at the enterprises with unit and small-series nature of production	DOS YeS	64	Assembler	
1.2.29. "PERT" software system	Used both in solving the problems of the control of the construction organization and when solving the problems of the control of the technical preparation of production	DOS YeS	128		

1	2	3	4	5	6
1.2.30. "Labor normatives processor" PPP	Designed for determining the normative labor consumption and value per production unit on the level of the section, the shop and the enterprise	DOS YeS		Assembler	
	2. Applied Programs for the Systems for Automating the Planning and Design and Technological Process Developments				
2.1. "Planning and design control" PPP	Used for solving complex problems of the control of modern complex scientific and research, technological and design projects	OS YeS	64	Assembler	
2.2. Set of programs for deciphering the composition of a complex product	Designed to solve problems of technical preparation of the production of automated production control systems	DOS YeS	64	Assembler	
2.3. "Planning and design control" PPP	Solves the problems of controlling the complex processe and the problems of operations planning and the control of their execution	DOS YeS	64		
2.4. "Product composition processor" PPP	Designed for the automation of the planning and design of software implementing the functions of calculating the applicability of parts,assembly units in a product in order to increase the quality of the design	DOS YeS	-	Assembler	

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1	2	3	4	5	6
2.5. "Materials standardization processor" PPP	Used for automation of the design of software which provides for calculations of the specific and summary norms for the consumption of materials for a product	DOS YeS	-	Assembler	
	3. Applied Programs for Scientific Research				
3.1. Applied programs (PPP) for scientific programs	Designed for solving the problems of statistics and mathematics	OS YeS	-	Fortran	
	4. Applied Programs for Special Application				
4.1. Generator of the program for compatible processing files	Designed for automation of the programming of the problems of processing economic information	DOS YeS	64	Assembler	
4.2. Generator of the information input-output programs for documents of complex structure for the unified system of computers (GVV)	Used for automation of the programming of the procedures of inputting the economic information prepared on machine carriers	DOS YeS	32	Assembler	
4.3. PPP-ASPI (information retrieval system)	-	OS YeS			

1	2	3	4	5	6
4.4. ASO PPP (information retrieval system)	-	OS YeS			
4.5. "Lambda" PPP (factographic information retrieval system)	-	DOS YeS			
4.6. "Pegas" package of applied programs (PPP-"Pegas")	Designed for the creation of information retrieval systems on the basis of unified system of computers realizing the functions of the formation, correction, retrieval, processing and output of information of various nature on request	DOS YeS	64		
4.7. "Monitor" PPP	Designed for the conversion of a simplified assignment control language to standard language and also for the organization of debugging	DOS YeS	64	PL/1, Assembler	
4.8. Generator of data preparation programs	Used as means for data preparation	DOS YeS	128		
4.9. "Information input and monitoring" PPP	Designed for the automation of the programming of the procedures for the creation and servicing of the files of normative-reference information and also for the input, monitoring and correction of operative information	DOS YeS	64	Assembler	

1	2	3	4	5	6
4.10. "PPP "Automated production control system generator"	Used for insuring the automation of the time of the programs for solving the problems of the functional subsystems of the automation production control systems to the conditions of the industrial enterprises with respect to its parameters	DOS YeS	64	Assembler, Cobol, PL/1	
4.11. "Output system" PPP	Used for output of the output forms to the printer and the screen of the Ekran-M system, the configuration of which can vary within quite broad limits	DOS YeS	64	Cobol, Fortran, PL/1, RPG, Assembler	
4.12. Input generator	Designed to create operating programs for the input of economic information, monitoring, formation and output of the composed files to external carriers	OS YeS	64	Assembler	
4.13. "Report generator" PPP	Designed for output of the results of solving the mathematical programming problems in the form of a report of arbitrary form	OS YeS	128		
4.14. "Information input and monitoring" PPP	Designed for automation of the programming of the procedures for creating and servicing the normative reference information files and also for input, monitoring and updating the operative information	DOS YeS	64	Assembler	
4.15. "Program Compiler" PPP	This is a set of programming means for the automation of the preparation of programs oriented to the solution of the problems of branch automated control systems	DOS YeS		YaDK, VYaKL	

1	2	3	4	5	6
4.16. "Sekunda" software system	Designed for automation of the programming of the standard procedures for processing economic information, and it provides the programmer with means of checking the developed modules	DOS YeS	-	Assembler	
4.17. "Information retrieval system-1" IPS-1 PPP	Designed for creating information retrieval systems that realize the functions of gathering, accumulating, storing, updating, retrieving and output of document and factographic information	DOS YeS	64	-	
4.18. "Information support generator" PPP	Used for the generation of the planning documentation of the automated control system and generation of the tables of the parameters for the adjustment of standard programs designed for various types of processing of information files for the parameters of specific files	DOS YeS	64	Assembler	
4.19. "Tver' 2-OS" software system	Used to create the software of automated control systems for organizing the communications between the problem-oriented programmers of the automated control systems and the information base	OS YeS	128	Assembler	
4.20. "Software of the remote processing systems" PPP	A problem-oriented means of coupling the input flow of the reserves to the library of processing programs	DOS YeS	128		

1	2	3	4	5	6
	5. General-Purpose Applied Programs				
5.1. PPP for solving the problems of mathematical programming (PPP-MP)	Mathematical programming system PPP-MP designed for solving the problems of linear and separable programming	OS YeS	44	Specialized basis of PL/1 and Fortran	
5.2. "Linear programming" PPP (PPP-LP)	Designed for solving the general problem of linear programming and analysis of the solutions obtained	DOS YeS	50	Fortran IV, Assembler	
5.3. "Generator of reports of the mathematical programming system" PPP (PPP-10)	Used to control the formation of the report or for the generation of data files which will be used for further processing in the PPP-MP	OS YeS, DOS YeS	44	Report language	
5.4. "Matrix processor of the mathematical programming system"	Designed for the analogous and the conversion of data pertaining to the problems of mathematical programming, operates under the control of the PPP-MP	OS YeS	128	Specialized	
5.5. "Partially integral programming" PPP (PPP-ChTsP)	Used to solve the problems of linear programming with the application of the requirement of integralness to the use of the problems or parts of them	DOS YeS	64	Assembler, Fortran	
5.6. "Systems software" PPP	-	OS YeS	-	-	
5.7. "Optimization" PPP	-	-	-	-	

1	2	3	4	5	6
5.8. Software system, PERT planning (SMO SPU)	Designed for processing the networks reflecting the processes of the planning and design, control or creation of the objects	DOS YeS	128	-	
5.9. "Nonlinear programming" PPP	A general-purpose package designed for solving the problems of nonlinear programming with restrictions in the form of nonlinear inequalities	DOS YeS and OS YeS	128	Fortran IV, Assembler	
5.10. "Linear programming in the automated control system" PPP	Designed for the solution of the problems of linear, separable, parametric programming and also problems with partially or completely integral variables	OS YeS	128	Fortran	
5.11. "Mathematical programming" PPP	Used as the basic mathematical means when solving various optimization problems in the different automated control systems	OS YeS	128	Fortran, PL/1	
5.12. "Mars-Model-IES" software system	Designed for organization and management of a hypothetical model of an information-economic enterprise control system	OS YeS	-	Assembler, PL/1	
5.13. "Gradient" PPP	Designed for analysis of nonlinear mathematical models	DOS YeS	64	Fortran IV	
5.14. "Organization of the computation process" PPP	Designed for the automation of the planning of the sequence of solving the problems of the automated control system on computer during the day and in order to provide for the effective implementation of the compiled plan	DOS YeS	64	-	

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1	2	3	4	5	6
5.15. "Integral programming" PPP	Used to solve the partially integrated problems of linear programming in which the integral variables are boolean	OS YeS	256	Fortran, Assembler	
5.16. "Integral programming by random search" PPP	Designed to obtain the approximate solution to the problem of integral programming with linear restrictions	DOS YeS	128	Fortran, Assembler	

[389-10845]

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MEANS OF FORMALIZED DESCRIPTION OF THE VTsKP* DATA

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[Article by G. M. Belash, O. M. Veynerov, M. S. Kazarov]

[Excerpts] Let us proceed with the analysis of the SFOD [means of formalized description of data]. Let us briefly consider the SFOD oriented toward the data administrator and the applied programmer, discussing only the events illustrating the arguments and conclusions presented below.

Let us remember that the data administrator develops the structures of the data in the base, constructs the data base system, achieving efficient functioning of the base for the entire complex of problem programs using it. The administrator is responsible for the physical organization of the data.

The layout of the data base reflects the general structural laws characteristic of the entire set of specific data fixed in the base. These laws basically are determined by the logic of the subject region depicted in the data base. The layout of the data base is described by the language means of definition of the data (YaOD) which must provide for the following:

The description of various types of structures generating the structure of the data base (that is, the description of the parameters of these structures -- names, formats, types of data, indication of keys, and so on);

Description of the relations between the generating structures and the layout of the data base.

In addition, the YaMD [data manipulation language] can be used to describe the layout of the protection of the data base from unsanctioned access and the attributes of the protection layout.

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*Collective-use computer center

The applied programmer (the problem-oriented user) communicates with the data base using the data manipulation language (YaMD), the operators of which either are included directly in the procedural (the procedure-oriented) language or they are formed as references to the procedure.

The functions of the YaOD [data definition language] are as follows:

The specification of the reference to the data base (search, reading, replacement, removal, and so on);

Definition (by indicating the types of structures and the corresponding names) of the attributes of the base layout used to localize the data with which the manipulations are performed;

Indication of the specific values of these attributes (and also the logical functions of the values, the ranges of values, and so on).

The YaMD can be used also to indicate the values of the protection keys.

The systems committee KODASIL has performed a detailed analysis of the structural principles of the YaOD and the YaMD, the results of which are reflected in [1]. On the basis of the performed analysis and generalization of the KODASIL, proposals have also been developed with respect to standardizing the YaOD and YaMD. These proposals have been described in detail, for example, in [2].

When creating the first stages of the VTsKP, obviously the "Oka" SUBD became widespread, which at the present time is the most powerful among the systems of this type available for application.

The structural principles of the means of definition and manipulation of data "Oka" have differences from the principles of the KODASIL. Accordingly, let us remember the basic principles of the organization of the YaMD of the "Oka" system (YaMD is not a system term). This is needed to compare the YaMD and other means of formalizing the description of data which will be considered below.

"Oka" supports the following types of structures: field, segment, entry, data base.

The entry is the set of segments among which the hierarchical relations are established. The data base is an ordered set of entries.

The system provides for the following types of references to the data base.

GET UNIQUE (GU).

GET NEXT (GN).

GET NEXT WITHIN PARENT (GNTP).

GET HOLD UNIQUE, GET HOLD NEXT, GET HOLD NEXT WITH PARENT.

REPLACE.

INSERT.

The analysis of the means of formalized description of data performed in the article has made it possible to determine the relation of the SFOD oriented for people of different categories, interacting with the automated data bank of the VTsKP and to draw the following basic conclusions.

1. The data definition language with respect to the SFOD of the applied programmer performs the functions of a metalanguage of the description of the grammar.

2. The organization of modern SFOD of the applied programmer SUBD with the base language insures potential possibility of constructing the simple translation algorithms from the IPYa [information retrieval language] of the final user.

3. The requirements which must be satisfied by the IPYa of the final user of the automated data base agree well with the principles of the organization of the modern SFOD of the automated control system.

4. The orientation to the mentioned requirements permits the construction of a simple interface of the SUBD with the file user adjusted to the specific application.

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AUTOMATION OF THE PREPARATION OF PRODUCTION BASED ON MACHINE TOOLS WITH DIGITAL PROGRAM CONTROL AT THE VTsKP

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[Excerpt] Summing up the results of what has been stated, let us consider two problems of the operating efficiency of the "Stop-2" system.

1. The analysis of the operating experience of the machine tools with digital program control indicates that for effective utilization of them in small-series production it is necessary to repair about 200 UP [control programs] per year per machine tool. At the same time for the preparation of one control program of medium complexity (on the order of 150 frames) using the existing SAP [automated preparation systems] the following are required:

About 10 to 15 hours to design the technological process;

About 40 hours for the preparation and checkout (including on the machine tool) of the control program.

Here the required machine time will be 0.5 to 0.6 hours, and the calendar preparation time and checkout time for one control program will reach 20 days.

The analysis of the possibilities of the "Stop-2" system indicates that as a result of using the standard elements of control programs the labor consumption of the technological process design is lowered by 2 or 3 times, and the time for checkout of the control program is reduced by 30 to 40%, for the necessity of debugging work is excluded in the sections of the controlling programs where standard solutions were used. The calendar time for the preparation of one controlling program decreases as a result of the dialog mode of operation of the remote user from 20 to 4-5 days, that is, it is reduced by 4-5 times by comparison with the existing systems.

2. The operation of systems similar to the "Stop-2" system is a fruitful and economically expedient basis for the interrelation among the industrial enterprises and the VTsKP. On the one hand, the enterprises avoid the necessity for bearing the expenditures on the acquisition and the operation

of the expensive all-purpose computers, the operation and the development of the labor-consuming and complex software for the automated systems to prepare the control programs, including the developed libraries of standard elements of the control programs. On the other hand, the collective-use computer centers obtain a reliable partner with a stable demand for machine time in the person of the industrial enterprises.

Actually, at the present time the fleet of machine tools with digital program control in the country is on the order of 30,000 which determines the demand for the preparation of 6 million controlling programs per year and, consequently, the requirement along the order of 2-3 million hours of machine time.

With respect to the VTsKP of the industrial region it is possible to make the following calculation. Servicing 10 or 15 large industrial enterprises with a fleet of machine tools with digital program control on the order of 50 units in each, the VTsKP can realize 50,000 to 75,000 hours of commercial machine time per year for operations with respect to automation of the technical preparation of production on machine tools with digital program control alone. Considering that the system permits simultaneous servicing of up to 10 subscribers, the demand for the calendar machine time will be about 6,000 hours per year, that is, a daily load of one of the YeS-1033 computers will be reached. The planned increase in the fleet of equipment with digital program control by 20 to 25% by 1980 insures further stable growth of the machine time demand. Here it must be noted that when preparing the control programs the operating time of the processor will be 50 to 60%. This is a great prerequisite for increasing the profitableness of the collective-use computer centers as a result of solving the background problems and to reduce the expenditures of the enterprises to lease machine time as a result of lowering the price of one hour of machine time in the time-sharing mode of the computer.

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Publications

ARTIFICIAL INTELLIGENCE

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[Book by Nikolay Mikhaylovich Amosov: "Intelligence Algorithms." Printed by the order of the Editorial Board on Popular Scientific Literature of the Ukrainian SSR Academy of Sciences.

Number of copies printed -- 37,000.

[Additional selections from this source appeared in a previous issue of this report -- see JPRS L/9204, 23 July 1980, pages 148-149]

[Text] Introduction

Intelligence mechanisms interest scientists of various specialties. For psychologists and physiologists -- it is the theory of their sciences; for cyberneticists -- it is ways to create artificial intelligence (II). In this book being offered to the attention of the reader I will attempt to present concepts on this problem -- as a result of the development of work being done in the Biocybernetics Department of the Cybernetics Institute of the Ukrainian SSR Academy of Sciences and which started in 1962. New ideas differ considerably from those published previously [1-3].

The work "algorithm" was not introduced into the title of the book by chance: I believe that it is possible to "pigeon-hole" the most complex manifestations of intelligence -- even with prospects of its development to a higher level than human intelligence. Evidently I will not be able to convince sceptics -- for this it is necessary to reproduce intelligence algorithms in programs. Regrettably, there are great difficulties in this path. Perhaps the cited ideas will help the enthusiasts of this problem? I warn that the subject is exceptionally complex to understand inasmuch as it lies at the junction of physiology, psychology, engineering and even philosophy. For simplification I will use block diagrams widely.

Intelligence is defined as a totality of means and methods to control complex systems by operating their models, directed by criteria of optimal control. Modern science and technology make it possible to reproduce models and operate them by technological means and thus separate intelligence from the brain to which it is usually related. The difference between the cited definition and the multitude of others consists in that it stresses this last circumstance.

Thus, speaking of intelligence, we will have in mind this totality of means and methods of control independently of whether it is realized in biological systems or by means of artificially created technological means. This use of the term "intelligence" is not generally accepted. However, it is closely related to the basic idea of this book. In those individual cases where we speak only about natural human intelligence, this will be mentioned specifically. As far as the term "artificial intelligence" (II) is concerned, it, as will be assumed, will be used to designate various kinds of technical implementations of intelligence models.

We will dwell on the basic concepts in order to enter the scope of the problems discussed gradually. First of all, it is necessary to separate out two opposite approaches to simulating intelligence. Conditionally, they may be called network and algorithmic. Correspondingly, we will differentiate between two types of models -- network (SI) and algorithmic (AI) intelligences.

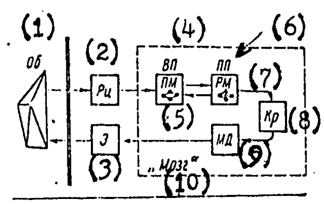

Fig. 1. Block diagram of network intelligence (SI).

1. ob -- control object
2. Rts -- receptors
3. E -- effectors
4. VP -- temporary memory
5. PM -- primary model
6. PP -- permanent memory
7. RM -- recognized model
8. Kr -- criteria
9. MD -- action model
10. "Brain"

The simplest block diagram of a network intelligence represents some complex three-dimensional structure. It is sensed by sensors -- receptors Rts (for example, eyes) and is transmitted by signals to the "brain," where it is converted to the primary model PM. To a first approximation, PM is represented by a flat two-dimensional structure, made up of excited, activated components of some network -- conditional "receptor field." The object is recognized by superimposing PM on a multitude of figures of inactive components, joined by "itineration" ties. These inactive model figures represent models of already known objects and make up permanent memory PP. In accordance with the principle of operation, SI components that make up the permanent and temporary (or active) memory -- are one and the same; they differ only in the level of activity. The superimposition of the primary model on the network selects and activates one recognized model of figure RM and from it a controlling effect is connected to the object. This effect is represented by the action of model MD, controlling effectors E. The recognized model of the object is tied to several action models; the selection of the needed one is determined by criterion Kr. The action model activated from RM and Kr transmits the activity to the effectors in which the control signals are converted into the mechanical energy of the controlling effect. Thus, in a network intelligence "the actions with the models" are represented by the change in the activity of the components of the networks in which the models are built in.

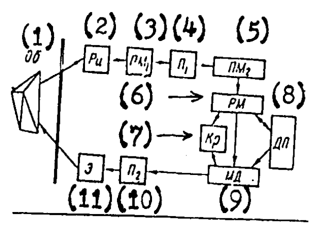

Fig. 2. Block diagram of an algorithmic intelligence (AI):

1. ob -- control object
2. Rts -- receptors
3. PM_1 -- primary structural model
4. P_1 -- converter
5. PM_2 -- primary digital model
6. RM -- recognized model
7. Kr -- criteria
8. DP -- long-term memory
9. MD -- digital action model
10. P_2 -- converter
11. E -- effectors

Fig. 2. shows a block diagram of an algorithmic intelligence. It starts functioning in the same way as in the SI, -- as a result of receptor Rts operation primary structural model PM_1 forms a two-dimensional structure in the same plane. However, it is immediately read-out by converter P_1,

transforming it into a linear, single-dimensional model consisting of a set of digits -- PM_2. All further actions are implemented by this model. PM recognition consists of its sequential comparison with standard models recorded by the same code in long-term memory DP, where recognized model PM is located. Action model MD is selected in accordance with this model. This process is implemented by sorting models in the long-term memory under the control of criterion Kr. The action nodel is transferred to converter P_2 where the digital code is converted into effector E controlling signals and through action controls -- to object Ob.

The basic difference between SI and AI is in the structure of the memory and the resulting various actions with models. However, in both types of intelligences, the principle of controlling the models from the side of the control criteria through their activation is preserved.

The creation of SI and AI assumes the use of various methodological approaches to simulating one and the same object -- human intelligence. Each of the approaches has its strong and weak points. Therefore, in designing actual II systems, it may be feasible to represent several intelligence functions in the form of network models and some others -- in the form of algorithmic models. The general principle here is as follows: the lower the level of the function being simulated in the general hierarchy of intelligence functions, the more probable it is that the network method is the most efficient in reproducing the II.

The situation is that the implementation of many functions of the lower level (such as, for instance, finding the recognized model in accordance with the primary model-- see Fig. 2) means a great amount of sorting in the long-term memory. Such sorting is most efficiently implemented in the network models that realize parallel processes of data reprocessing. At the same time, network models have other shortcomings that limit the areas of their application. I will dwell many times on the comparative analysis of the advantages and disadvantages of network and algorithmic models.

A number of papers are dedicated to problems of creating SI and investigating their properties. Brief reviews of concrete results that have been obtained are given in the first section of this book. The rest I will dedicate to the description of AI design principles, not making any further special stipulations that, in its practical implementation, a number of functions may be represented by network structures.

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